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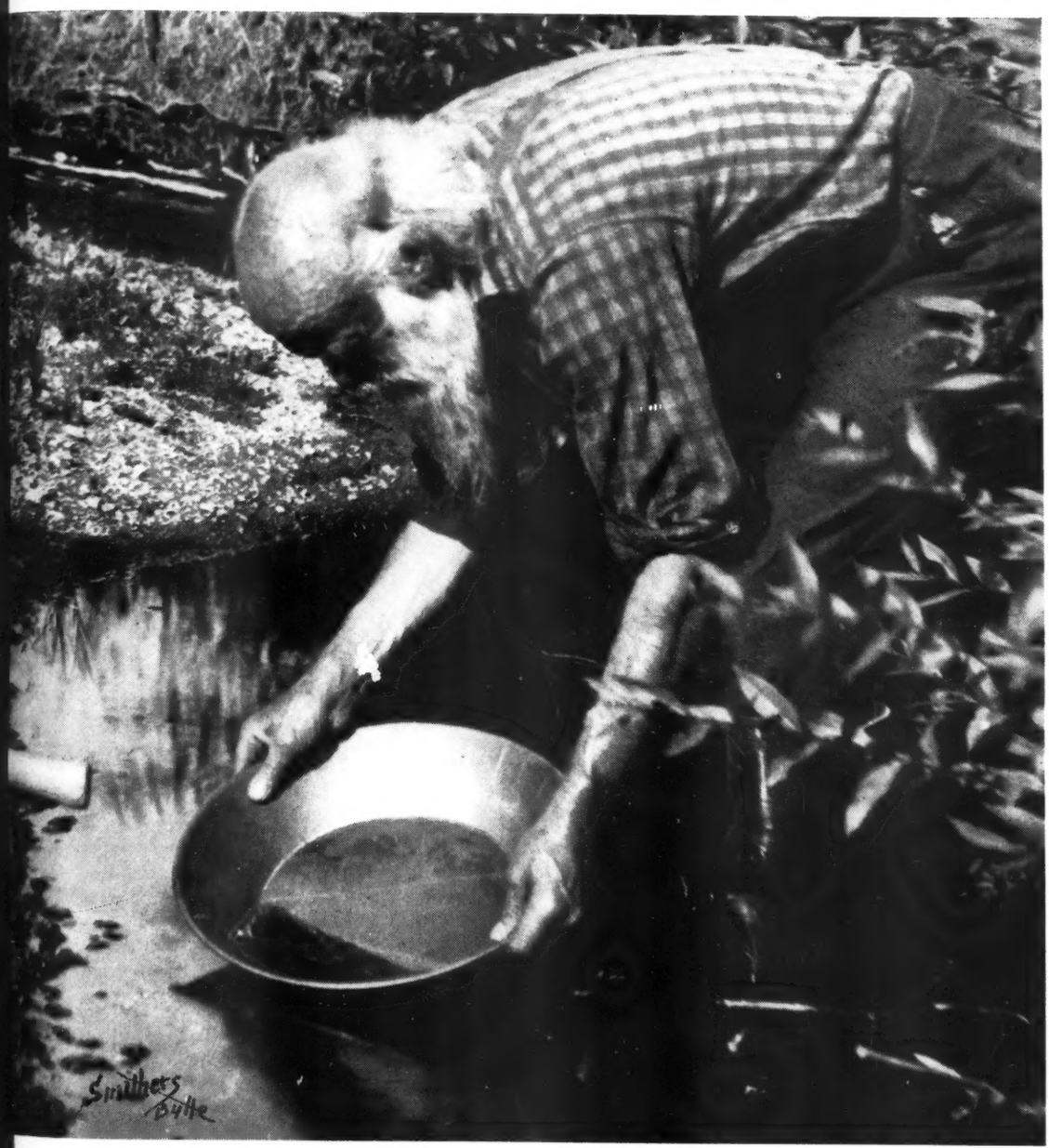

THE GOLD PANNER

VOLUME 51 • NUMBER 11

NEW YORK • LONDON

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THE Treasury Department is asking everyone to buy an extra Savings Bond between November 11 and December 7. There will be no solicitation, so it is up to each individual to act on his own. Eighty percent of all companies employing more than 100 persons are continuing the payroll-deduction purchase plan. The bonds also are on sale at banks and post offices. An investment of $18.75 a week in these bonds will aggregate $10,828.74 in ten years.

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ON THE COVER

TYPICAL of a breed of men that is disappearing too fast is the prospector pictured on our cover. Modern scientific methods of searching for ore, including reconnaissance from the air and geophysical work on the surface, are doing a good job, by and large, but the storied man of pick, pan, and burro is hard to replace. Mining associations everywhere are deploring his passing from the scene and are making special efforts to interest men in the quest for ore and to impart to them the rudiments of mineralogy. The old-time prospector was part and parcel of the pioneer West, a colorful figure whose optimism never died. Our portrait was made by C. Owens Smithers of Butte, Mont. An enlargement of it appears, with other early Montana scenes, in the Copper Bowl—grillroom of Butte's Finlen Hotel.

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IN THIS ISSUE

AMERICA'S most famous open-pit copper mine is the Kennecott Copper Corporation's Bingham Canyon bowl in Utah. Similar to it is the smaller but still sizable Santa Rita pit operated by the same concern in the Silver City area of New Mexico. Our leading article takes the reader on a tour about the workings and on to Hurley where the ore is smelted and the metal refined.

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THE milk you drink, countless processed foods you eat, and many of the pharmaceutical products you use are pure because they are treated or made and transported in sanitary equipment with the exercise of scrupulous care against contamination. In almost every plant that handles any of these things there are Pfaudler tanks, piping, etc. How this came about is told in the article starting on page 292.

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AN OMISSION

IN AN October editorial, *Gas-Turbine Research*, it was mentioned that Allis-Chalmers Company is building a 3750-hp. coal-burning gas turbine for use in an experimental railroad locomotive. We are now informed that a similar gas turbine is being constructed by Elliott Company of Jeannette, Pa.

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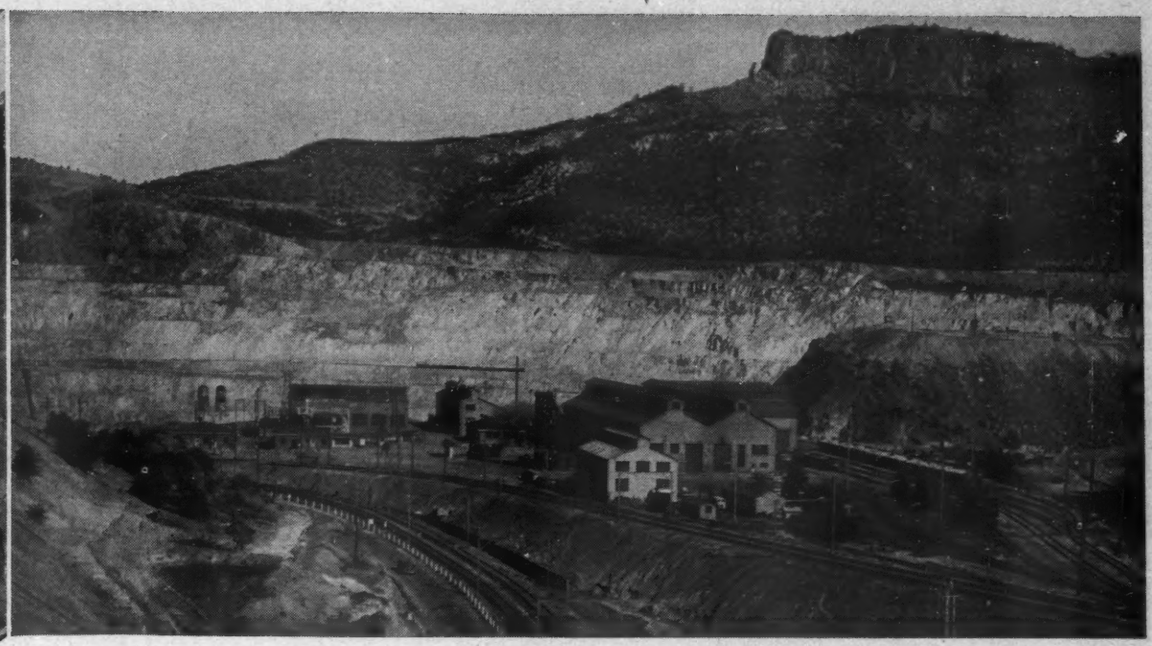
By
L. A. La

Chino Copper

GREAT sources of raw materials such as the iron mines of the Mesabi Range and the several similarly operated open-pit copper mines on this and the South American Continent proved indispensable reservoirs to our military during World War II and gave us preponderance despite huge Axis stock piles, supplemented by the pillaging of conquered countries. The vastly increased use of aircraft and antiaircraft ordnance, together with the multiplied rate of fire of every type of automatic weapon, including small arms, high lighted the strategic advantage we possessed in having an abundance of copper. One of the famous open pits that contributed substantially to our military needs, working three shifts daily throughout the recent conflict, is operated by the Chino Mines Division of the Kennecott Copper Corporation at Santa Rita, N. Mex.

Ancient peoples discovered that green rocks burned in charcoal left lumps of red metal and learned early to prize copper for ornamentation and utility. The Island of Cyprus was noted as a source of that mineral as far back as 3000 B.C., and Ionians, Greeks, and, finally, Romans worked the mines until they were supposedly exhausted. For hundreds of years they were forgotten. Until the turn of the last century prospectors sought only rich concentrations of copper, and many ore bodies of incredible extent and richness were located. But copper exists in many forms, sometimes in huge boulders and wedges of virtually pure metal the very size of which frustrated early operators. In Michigan were found great masses of conglomerate in which pebbles were held in a matrix of the red metal. Virtually all the vast deposits now being mined by the open-pit method were probed for years with the expectation of locating rich ore. One group working Santa Rita cherished the hope of making it a second "Butte"—the equal of Anaconda's famous deep-mine district.

Santa Rita is in what is generally referred to as the "Silver City Mining Area," which comprises a section of about 33 square miles and which has a mean annual rainfall of 14 inches. In addition to



GENERAL VIEWS

At the top-left is the 400-foot-deep open pit, with the town of Santa Rita at its right. The ore is extracted from a series of benches and loaded by power shovels into railroad cars, center. The mine shops (above) are conveniently located in the pit. The mill and smelter (bottom-left) where the ore is treated are at Hurley, 10 miles from the pit. Early Spanish miners at Santa Rita erected a fort to protect them from marauding Apache Indians. During the Civil War it was occupied by Confederate forces, which presumably obtained some of their needed copper there. A restored tower—one of three that originally guarded the fort—is pictured below the article heading.

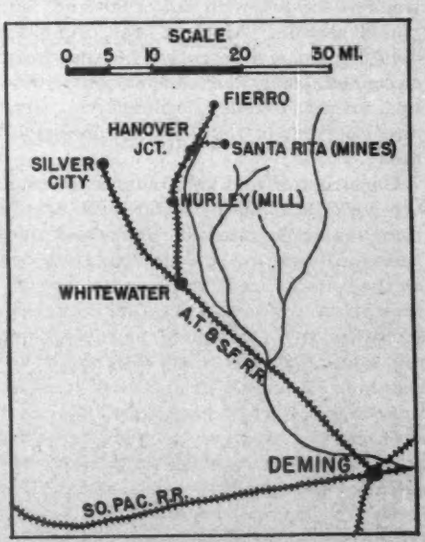
copper, the district produces considerable quantities of lead, zinc, and silver, and some iron ore has been shipped to the Colorado Fuel & Iron plant at Pueblo, Colo. The area even had a brief gold rush in 1903 when yellow metal was discovered in Gold Gulch. The Kennecott copper pit is at an elevation of 6235 feet. With a depth of 400 feet, it now has the appearance of a miniature Grand Canyon, the exposed strata of its benches having a coloration somewhat like that of the Painted Desert in Arizona.

The deposit was the scene of active surface and underground mining for many years before it was opened with steam shovels in 1910 and is said to have been shown in 1800 by a friendly Indian to Colonel Carasco, who was in charge of a Spanish military post. Title to the property was long held by Don Manuel Francisco Elguea, a wealthy merchant from Chihuahua and subdelegate to the Spanish Court. Elguea had sufficient influence to effect a contract with the province of New Spain, which agreed to take all the output of the mine for copper coinage. The metal was transported by pack-mule train under convoy to Chihuahua and Mexico City.

Not all the local Indians were friendly, the Apaches of the Southwest being irresistibly drawn to any fixed enterprise for their favorite pastimes of sniping and looting. There still stands at Santa Rita a thick-walled adobe tower that was one of three at the apexes of a triangular fort with barracks used by a Spanish garrison. The hazards of operations in those days may be judged by the fact that McKnight, one of the first Yankee owners, employed the famed scout Kit Carson as a teamster in 1834. One researcher states that copper production had increased to such an extent between 1858 and 1861 that a million pounds was hauled by wagon some 800 miles to Port Lavaca, Tex., whence it was shipped to New York by sailing schooner. The old fort disclosed evidences of occupation by Confederate forces, giving rise to the assumption that some of the considerable stock of copper confiscated by Gen. H. H. Sibley when he held the El Paso area for a time may have served the Confederacy for military purposes. It was a contingent of those gray-clad troops that followed the Rio Grande 300 miles toward its headwaters, only to be routed by a group of mountain men from Colorado mines at Glorieta Pass in the most northwesterly battle of the Civil War.

Some mining veterans now on the staff at Santa Rita who worked on the property as boys remember loading half a car of ore that ran 92 percent copper. They recall the mementos of early Spanish operation —small slag dumps, ruins of old furnaces and of charcoal-burning pits along the hillsides. Perhaps the crude techniques they exemplified were carried over from the Rio Tinto smelters of old Spain, although the old Santa Rita slag dumps are said to have contained much copper while the efficient extraction at Rio Tinto never has ceased to baffle metallurgists.

Elaborate exploration with churn drills preceded the opening of the Santa Rita pit, and charting of the ore body is still in progress. Overburden ranges from a few feet to 150 feet deep, and one area has been found where material containing chalcocite and metallic copper continues to a depth of 1300 feet. Two 3½-yard, railroad-type steam shovels with which to start operations were ordered prior to 1910. The fact that makers of all kinds of mining and milling equipment were at some pains to keep pace with company

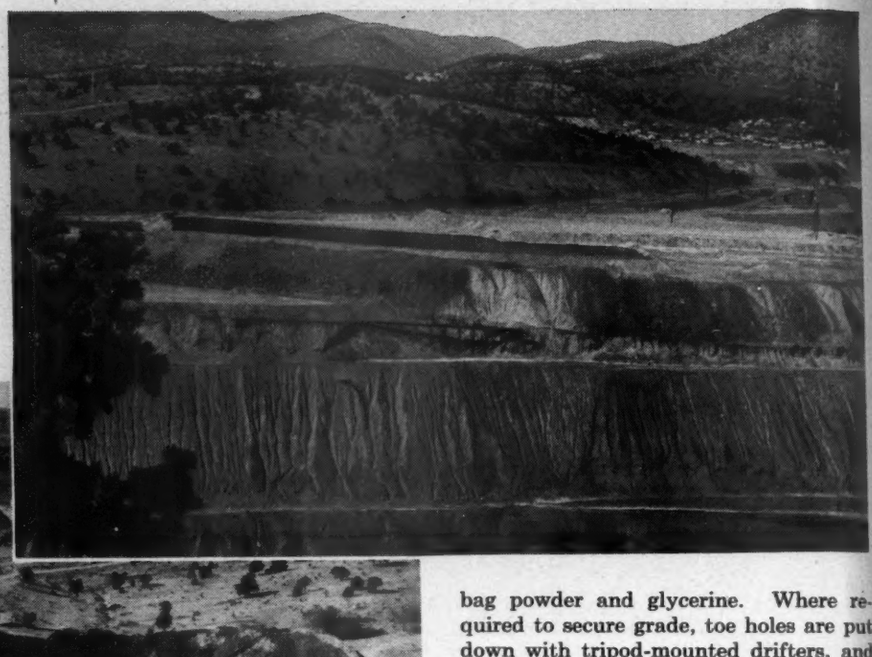


LOCATION MAP

Chino Mines operations are in the Silver City District of southwestern New Mexico.

LEACHING OPERATIONS

Approximately 750 tons of copper is recovered monthly by the percolating action of water that descends through the huge dumps of waste. As air reaches the small percentage of copper sulphide that the rock holds, it oxidizes it to a soluble sulphate that can be leached out. At the right is a typical view of a dump undergoing leaching. The other picture is of the plant at Santa Rita where the copper is captured by directing the solution over ferrous scrap. The copper sulphate replaces the iron and is subsequently reduced to metal by smelting.



officials' concepts of capacity is evidenced by the evolution of the shovels in the Santa Rita shops from rail to self-propelled caterpillar type and from steam to full electric drive. Eight of the latter class are now employed there—seven being of 5-yard and one of 8-yard capacity. There are 35 miles of standard-gauge track at the pit, with rail of 90- and 130-pound section. Haulage was originally done by steam locomotive but has been electrified, and thirteen 85-ton, 1000-hp., overhead-trolley locomotives, using direct current of 750 volts, are in service today.

Construction and maintenance of track are important phases of open-pit operation, for track must be assembled and periodically shifted considerable distances on the benches. So that this may be done expeditiously, track is prefabricated with screw spikes in complete panels of one rail length, in which form it is hauled to location, set in place, and tied to contiguous members by joint bars. Where a shift must be made, sections are similarly lifted and moved, one at a time, by boom-equipped tractors with special slings. To further mechanize the work, a 315-cfm., self-propelled compressor supplies air to operate such track tools as tie tampers, cut-spike drivers, screw-spike drivers, joint-bolt wrenches, a rail drill, and a wood borer. Adjacent to rail entrance into the pit is a large modern shop provided with machine tools, cranes, and other essentials for the maintenance and complete overhaul of all rolling stock, power shovels, trucks, etc., as well as for conditioning drill steel and detachable bits.

Maximum grade of track in the pit is 2.5 percent. Train movement is controlled by telephone, with some semaphore signals from a central tower. This is possible because the good visibility prevailing at Santa Rita usually makes observation of equipment moving in the pit as accurate from the tower as from an illuminated chart in a centralized traffic-control station. Roadways lead to all parts of the pit, and some use is made of track motor cars. Buses pick up and drop employees at working places, and several long routes are maintained for the convenience of those living beyond a company-built residential section above the main mine offices in Santa Rita.

The average height of the benches is 50 feet, and principal production drilling is done by churn drills equipped with 9-inch bits. Holes are spaced in accordance with the formation, on an average 16 feet apart, and are drilled 5 feet below grade. Around 650 pounds of powder is used per hole, with an average breakage of 45 tons per foot. The character of the ground and the moisture content influence the choice of explosive from among different types of bag powder and glycerine. Where required to secure grade, toe holes are put down with tripod-mounted drifters, and considerable blockholing is done with hand-held drills, air being piped to all workings from a compressor house adjacent to the shop and containing two synchronous-motor-driven units 30&18x21- and 29&17½x21-inch in size.

A very substantial contribution to the Santa Rita copper output is made by leaching the vast waste dumps. To become soluble in water, the copper sulphide of the ore body must be oxidized to copper sulphate, and circulation of air through the broken mass facilitates this reaction. Leaching is not a new technique in copper recovery. Galen, physician to Marcus Aurelius, described it in 166 A.D. as a process of commercial proportions after seeing Roman slaves drive drifts just below water level in the worked-out Skouriotissa mines of Cyprus to catch surface water leaching through the porphyry. However, the sulphate thus secured was not converted into metal but was used in making pigments and dyes. Much earlier in recorded history, natural leaching was described as a phenomenon, a source of awe to ancient peoples, especially in connection with the Rio Tinto, or tinted river, which turned from red to brilliant green as it emerged from a canyon below great ore bodies. It was from the seaside village of Palos near the mouth of this river that Christopher Columbus embarked in 1492.

Moorish metallurgists of the Middle Ages, following in the footsteps of the Roman and more primitive workers of the famed Rio Tinto mines of the Spanish Peninsula, found that when water containing copper sulphate is allowed to run over iron it produces cement copper. Iron ores abounded in Spain, and the discovery led to a new method of mining in open quarries above the old Roman shafts then leaching the broken ore. The present practice of leaching the Santa Rita dumps

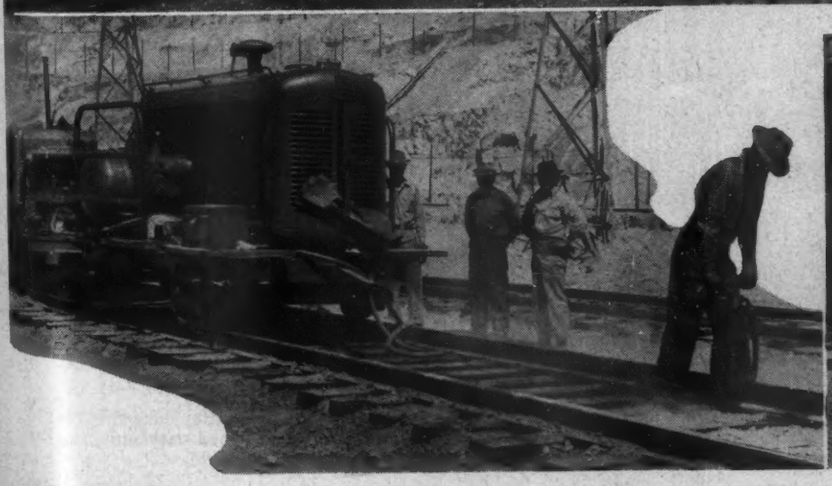
does not differ much from the old Moorish one, although such accessories as high-head, corrosion-proof centrifugal pumps and modern piping have greatly increased volume of output and efficiency.

Water varying from 1500 to 2000 gpm. is circulated long distances over large areas at maximum heads of around 350 feet and issues at the bases of the dumps as brilliant-green seepage or sulphate-laden springs. Better than a 99 percent recovery of the contained copper is effected in a central leaching plant consisting of a series of rectangular concrete vats at graduated levels. These vats are charged by a clamshell with ferrous scrap composed largely of shredded tin-can residue from detinning plants, there being nearly a pound-for-pound replacement of iron with copper. Water draining from the vats is recirculated. The red precipitate, which gradually turns black as it is dehydrated to an approximate 25 percent moisture content, is loaded by a clamshell into cars and shipped to a smelter at Hurley where, before smelting, it is dried in a gas-fired roaster. An average of 1½ million pounds of copper per month is thus produced.

Ore is loaded at Santa Rita into 80-ton cars which are made up by electric locomotives into 38-car trains in the mine assembly yard. The Santa Fe Railroad hauls these some 10 miles over its tracks to the Hurley material yard where it maintains a switcher 24 hours a day to move cars into the mill. It may be remarked in passing that Hurley contrasts somewhat with Santa Rita in that it is a model town built expressly to house and supply mill, smelter, and power-plant personnel, while Santa Rita, although also a model community, rubs elbows with a number of scattered villages that trace their beginnings to early Spanish-American colonization and from whose first American-mining families Kennecott still recruits many employees. Cars of ore, each carrying on an average 70 dry tons, are weighed on a track scale at Hurley and emptied by a Wellman car dumper onto a set of grizzlies in the crusher pit.

Ore from run-of-mine to 1 inch is crushed in two stages by an 84x66-inch jaw crusher and by three Symons standard cone crushers; secondary crushing, taking ore from 1 inch to ¼ inch in size, is done by 72x20-inch rolls in a closed circuit with screens. Transfer of material between crushing stages is effected by rubber belt conveyors, and storage bins with an aggregate capacity of 12,000 tons are provided between primary and secondary crushing and between secondary crushing and the ball-mill department. Below the bins are feeders which regulate the flow to subsequent points of operation. Dust-control equipment, consisting of suction fans discharging into dust collectors, are installed in both crushing buildings as a health measure, a total of 155,000 cfm. of air with entrapped dust being removed.

A layman's conception of the flotation process may be set forth as a method by which separation of minerals is accomplished in a mixture of finely ground ore and water to which certain reagents are added and into which large volumes of air are introduced, resulting in a rising column of bubbles. The mineral or minerals to be recovered, although often of a gravity greater than the solids left behind, are buoyed to the surface of the pulp and there skimmed off. Reagents used are numerous, but fall into three broad classes: conditioners, collectors, and frothers. Milk of lime comes under the first head and modifies the pulp or minerals, as the case may be. The second is chosen because it coats the particular material to be floated with a water-repellent film. The third class produces a mass of bubbles when air is introduced. The minerals with the water-repellent film attach themselves to the air bubbles and are carried by them to the surface, while those that have no film are water-wetted and consequently do not attach themselves to the bubbles. The process is said to have increased the



RAILROAD MAINTENANCE

There is more than 35 miles of standard-gauge track in the open pit and it has to be shifted frequently to keep pace with the extraction of ore from the various benches. To facilitate its movement, rails and ties are assembled in rail-length units that are moved by tractor-mounted cranes, as illustrated at the left. Other track-laying operations are expedited by using pneumatic tools that obtain their power from a 315-cfm., self-propelled air compressor. Spike-driving and tie-tamping views are shown.

recovery of copper by as much as 50 percent.

Grinding of the ore to make flotation practicable is done at Hurley in ball mills in two stages—primary-stage mills employing 3-inch balls and secondary 2-inch balls, the daily consumption of 20 tons of balls being cast in a foundry on the property. The mills are in a locked circuit with drag-type classifiers, and the end product, averaging 6 percent plus 65 mesh, is ready for flotation. The first chemical reagent—milk of lime—is added to the ball-mill feed, the lime rock from which it is made being mined locally and burned and processed in the plant. The function of lime is twofold: to provide an alkaline circuit for flotation and to render freshly ground iron-sulphide particles nonfloatable. The output of the ball mills is sent to thickening tanks, which remove some of the excess water used in classification. The discharge is returned to the mills and distributed to conventional Southwestern-type flotation machines supplied with agitating air at 1½ pounds pressure by rotary blowers. Reagents for the flotation circuit, in addition to lime, are butyl xanthate as the collector and pine oil as the frother. A fuel oil of light grade serves for the flotation of molybdenite.

Two valuable minerals are concentrated at Hurley: copper sulphide, which is predominantly chalcocite, and molybdenite. Nonvaluable iron sulphide in the form of pyrite, the quantity of which is several times larger than that of copper minerals, is rejected in tailings. The two most important characteristics of the ore body that determined the flow sheet and the type of reagents that would best meet requirements are the partial oxidation of the sulphides and the very intimate association of the copper and iron minerals. To float the tarnished sulphides it is necessary to use a strong collector. At times the oxidized portion reaches a value of 11 percent of total copper. Fine grinding is essential in order to liberate the copper and the iron sulphides, permitting the one to be recovered and the other rejected.

To achieve this end and to reduce the percentage of the material that must be finely ground, a preliminary, rougher concentrate is produced that is reground and refloated. The resultant concentrate contains both chalcocite and molybdenite and must again be separated. This is done by boiling the entire concentrate tonnage with live steam and subjecting it to flotation. In this final stage only those reagents are employed that float molybdenite, the copper minerals remaining in the tailings of the molybdenite recovery plant. The molybdenite concentrate is shipped in this form while the mill's principal values, the copper minerals in the tailings, are sent to a filter plant where they are dried and loaded in cars for delivery to the smelter.

Waste material, or tailings, is impounded in ponds each about 100 acres in extent, a total of 1000 acres being set aside for this purpose. At the present rate of production, 10 acre-feet of solids are deposited daily. It is of prime consideration that the method of impounding be such as to permit maximum water recovery because the supply for the entire operation comes from wells remote from the plant. The mill uses approximately 10,000 gpm., and as the total available supply for Hurley amounts to about 4000 gpm., the deficit must be made up from water recovered from thickening tanks and tailing ponds.

A powerhouse at Hurley generates all the electric current for the contiguous mill and smelter, the Santa Rita pit and underground workings, the deep-well pumps which handle the water, the domestic lighting circuits in both towns, and for other purposes. An interesting feature of the plant is that it was built in 1910 to serve a 5000-ton mill the capacity of which has been quadrupled since that time. Steam is generated by five low-pressure boilers and one high-pressure unit. The latter is of 3-drum construction with a water-cooled furnace and floor and operates at 450 pounds pressure, 770°F. maximum steam temperature. Its maximum capacity is 320,000 pounds per hour—the average current output of 180,000 pounds per hour representing about 65 percent of the plant's steam consumption. When combined with steam from smelter waste-heat boilers, it suffices to carry the normal load.

Natural gas from the Hobbs Field in eastern New Mexico reaches the mill at 400 pounds pressure and is reduced in three stages to 15 pounds at the burners. Boilers also are equipped for oil firing for emergency purposes. Feed water for the high-pressure boiler is 100 percent evaporated water, which is heated to 219° and delivered to it and to two waste-heat boilers by four 400-gpm., 5-stage centrifugal pumps, one of which is motor-driven and three are turbine-driven units. Feed water is treated first with a lime-soda ash retard automatic softener and then with zeolite.

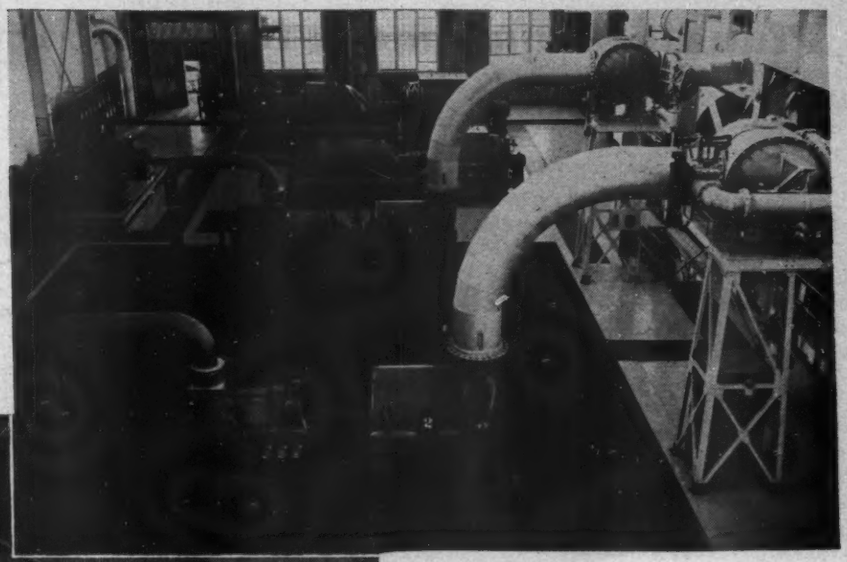
Three-phase, 60-cycle current at 6600 volts is developed by a 10,000-kw. turbo-generator using 450-pound steam and by a 7500-kw. unit using 180-pound steam. For the production of 3-phase, 60-cycle current at 480 volts there are two turbo-

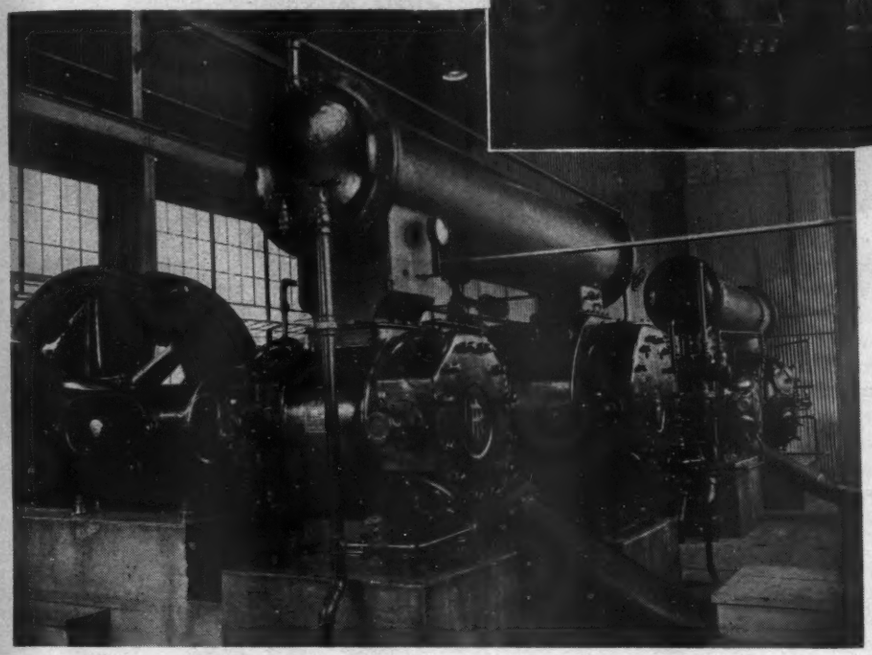
CONVERTERS AND CASTING MACHINE

Concentrate from the mill and precipitate from the leaching plant are treated in a reverberatory furnace, and the resulting matte is blown with air to produce blister copper in the converters pictured at the left. The blister copper is further refined in a gas-fired furnace and then cast into bars and other shapes on a rotary machine, right.

AIR POWER

Large amounts of compressed air are used in the mining operations at Santa Rita and also in the mill and smelter at Hurley. The two synchronous-motor-driven compressors shown below supply approximately 5500 cfm. of air at 100 pounds pressure for running rock drills and for various other purposes at Santa Rita. Four reciprocating compressors are in service at Hurley in addition to two turboblowers that are shown in the foreground of the view at the right. Each of these machines can deliver 25,000 cfm. of air at 18 pounds pressure. The air blows the copper converters illustrated on the preceding page.





generators, one of 2000 kw. and the other of 6000 kw., both using 180-pound steam. Steam is fed by automatic extraction from the one high-pressure unit to the low-pressure generators, along with steam from other sources.

All turbines run condensing, being equipped with single-pass surface condensers of suitable capacity. Cooling of condenser circulating water is accomplished in a 2,000,000-gallon open spray pond and by a 6-section, induced draft, double-flow cooling tower that was added in 1944. To maintain carbonate balance, the water is treated by a cold-process softener of milk of lime, sodium aluminate, and soda ash having a capacity of 600 gpm. Chlorine serves to control algae growth, with an occasional application of copper sulphate in the cooling tower for the same purpose. Water reclamation averages 60 percent.

Electric power is transmitted to the mine at Santa Rita at 24,000 volts and is stepped down to 750 volts for haulage and to other required voltages. Motor drives in mill and smelter use 440-volt current. Compressed air for general purposes in the mill and smelter is supplied by two 18&10¼x14-inch compressors with flat-belt drive from electric motors and by two 29&16x20-inch machines that are steam-driven.

Prior to 1938, the concentrate was hauled to El Paso for smelting. Today, the smelter adjacent to the Hurley mill, which was blown in in 1939, handles concentrate from the mill and precipitate from the leaching plant. These products are mixed and, together with lime rock, are carried by an electric vibratory conveyor from charging bins to a reverberatory furnace, which is charged seven times in an 8-hour shift. It is fired with natural gas from the Hobbs Field and uses preheated air. Matte drawn from the furnace is transported in ladles by 45-ton cranes and delivered to Pierce-Smith 13x30-foot converters, where it is blown to blister copper with air at controlled pressures averaging 13 pounds per square inch. The air is supplied at a maximum pressure of 18 pounds by two turboblowers, each having a capacity of 25,000 cfm. These units are installed in the power plant and are remote controlled by air-pressure governors located at the operating stations in the smelter, the air being carried a distance of 1580 feet through two 36-inch lines.

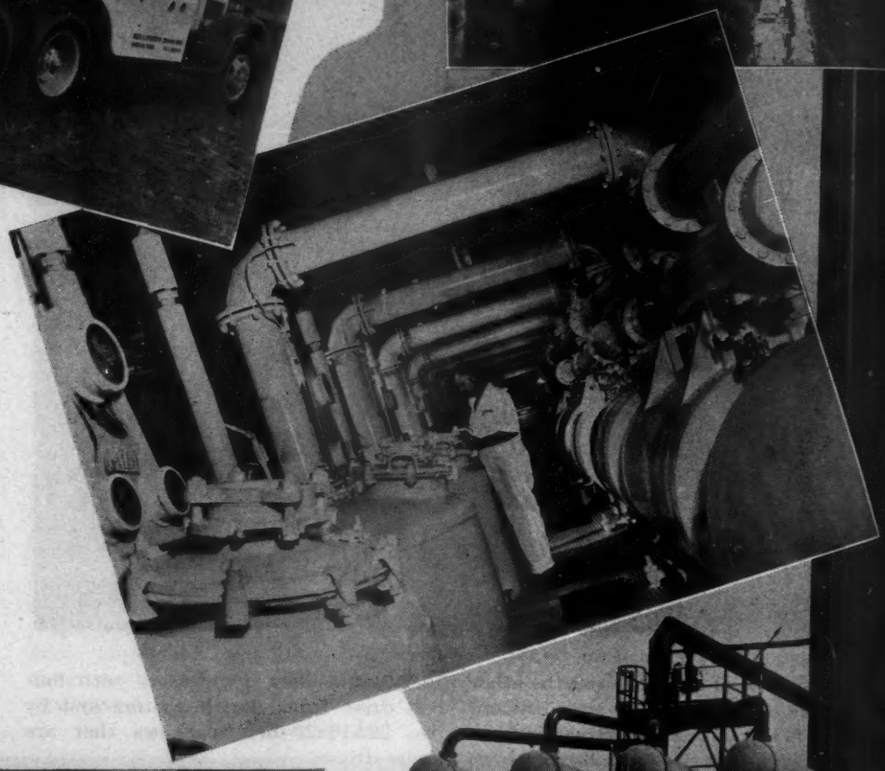
Each converter has an output of 60 to 70 tons of 99.4 to 99.6 percent blister copper which, in molten form, is discharged into ladles by rotating the converter and moved by crane to a gas-fired refining furnace. There it is further treated with compressed air to scorify impurities, and then green pine logs are burned to reduce the oxygen content to the desired degree. From the latter furnace the copper is cast into bars and shapes of several types. The multiple molds used for this purpose are of copper and are carried on an electrically driven walker-type casting machine that rotates somewhat after the manner of a carousel, with molds in place of seats. This machine automatically reverses the molds, spilling the partially cooled bars into a water bath. The removal of the castings is facilitated by spraying the molds with a bone-ash suspension, much like a housewife greases her cake pans. Upon emerging from the cooling vat on a metal conveyor, the product is inspected and much of it loaded directly into cars for shipment. Around 200 tons of copper is produced per day.

About 230 men are employed in the 3-shift operations at the smelter and refinery; approximately 770 men are engaged at Santa Rita in mining, in the shops, and at the leaching plant; and the mill and powerhouse have some 600 additional, making Kennecott's aggregate payroll in the Silver City area more than a quarter-million dollars monthly. The casual visitor finds it interesting to contemplate how great an outlay in man-hours and in out-size equipment at pit, mill, power plant, and smelter is required to keep a stream of red bars pouring from the furnace conveyor for a number of hours out of each twenty-four.

The writer wishes to express his thanks to the officers of the several plants for the generous assistance given him in the preparation of this article.

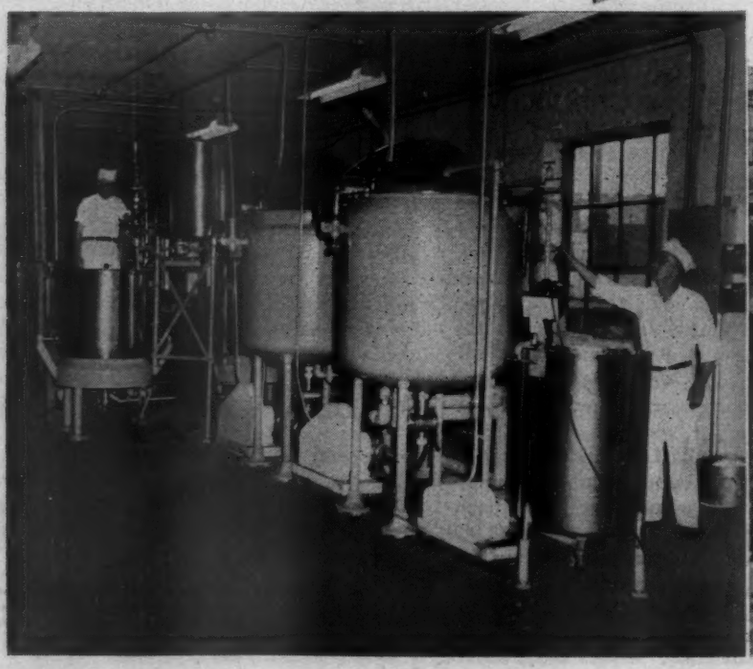
Pfaudler Equipment for Many Industries

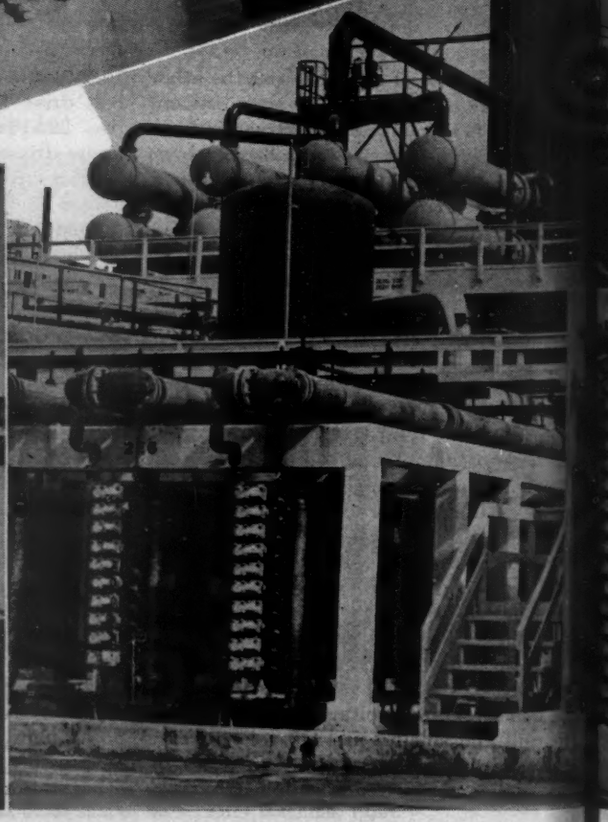
R. G. Skerrett



PFAUDLER EQUIPMENT

A 2290-gallon tank truck of stainless steel, one of many that are used for transporting numerous fluids from ice-cream mix to wine, is shown above. Some road vehicles of this type have capacities of 3500 gallons. Below is a view in a plant that makes salad dressing. Each of the stainless-steel tanks pictured at the top-right holds 2500 gallons of milk in storage until it can be processed. Typical of the equipment employed in the pharmaceutical industry are the glass-lined, partly jacketed steel stills at the right in which beef liver is processed under vacuum to produce extract. One ton of raw liver is concentrated to a volume of 9½ quarts. The manufacture of butadiene, a constituent of synthetic rubber, involves the use of sulphuric acid and other highly corrosive liquids, and apparatus for that purpose has to be selected accordingly. The heat exchangers in the foreground of the central picture contain 8500 feet of glass-lined piping.





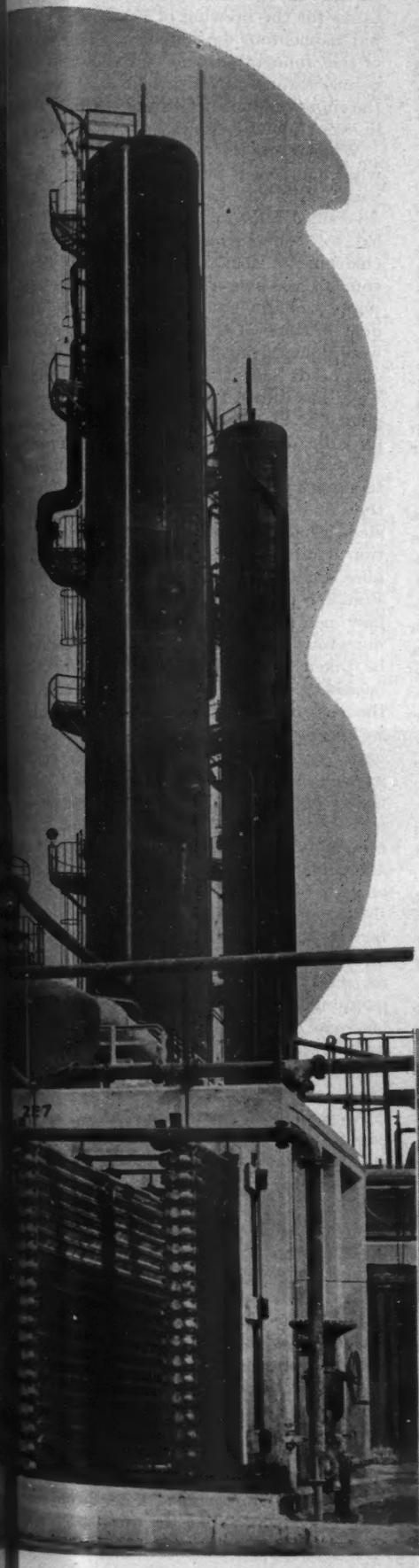
BUILDING a big business on vacuum as a foundation—that physical state which Nature is said to abhor—was the thought in mind originally of an industrial concern that has won success because of the variety and the ever-increasing uses to which its products have been put. Such, in brief, is the record of The Pfaudler Company of Rochester, N. Y. In the years that have intervened, the position attained by that concern in the manufacturing field is properly attributable not to vacuum but to the inventiveness, engineering resourcefulness, and business sagacity of the men allied with it since its beginning in 1884.

To the public at large, The Pfaudler Company is primarily associated with certain types of glass-lined tanks designed to transport bulk milk in large quantities for long distances over railroads or highways and secure the while from contamination or impaired freshness. But that is only one of well-nigh numberless applications of the diversified glass-lined containers and tributary equipment turned out today by this concern. Just as the organization started out to put vacuum to a novel use, it has in the years that have followed been receptive to new ideas which have been brought to practical application despite repeated setbacks and recurrent headaches for all concerned. And this brings us to the origin and the naming of the company and to the man who is so recognized for the role he played at its inception more than 60 years ago.

Caspar Pfaudler, a machinist and a resident of Rochester, had some knowledge about brewing beer, in which fermentation has an essential part. As the industry was practiced six decades back, fermentation was fraught with some uncertainties, and Pfaudler conceived the idea that it might possibly be speeded if the yeast were set to work under a partial vacuum, thus offsetting the known retarding action of pressure. Accordingly, he reasoned: "Why not ferment in a closed vessel and apply vacuum?" That thought was put to test, and Pfaudler's theory was found to be well grounded. Men of business standing and financial status saw the possibilities of the invention and organized themselves as the Pfaudler Vacuum Fermentation Process Company in December of 1884.

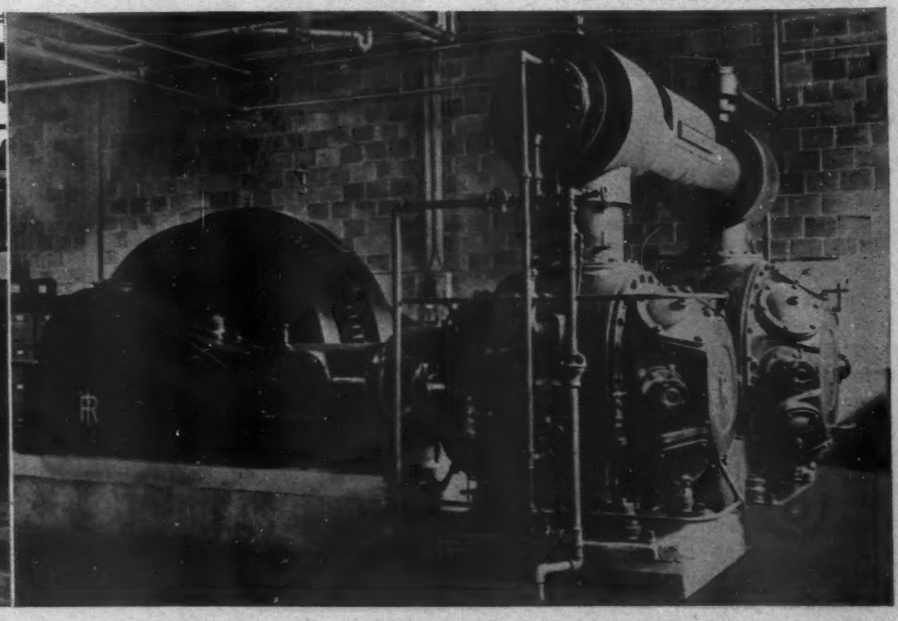
But the application of vacuum to fermentation was not in itself to prove a short cut to success in brewing—there were other problems that interposed difficulties, such as the impairment of the beer by reason of the corrosive action induced by contact with the metal walls of the apparatus used. It was necessary to provide "some kind of sanitary container that would hold a vacuum and serve the purpose of speeding up the fermentation of malt products." Nothing of that description was available in the supply market at that time, and several years of failure passed before ways were found to produce a successful glass-enameled steel tank. The first satisfactory containers were forged by the Continental Iron Works of Brooklyn, N. Y., the very people who had built the epoch-making armorclad *Monitor* of Civil War renown; the heads were made by the Hickson Locomotive Works of Scranton, Pa.; but the most momentous part of the task, the enamel lining of the tanks, was done in Rochester three years after the Pfaudler Vacuum Fermentation Process Company had been hopefully launched.

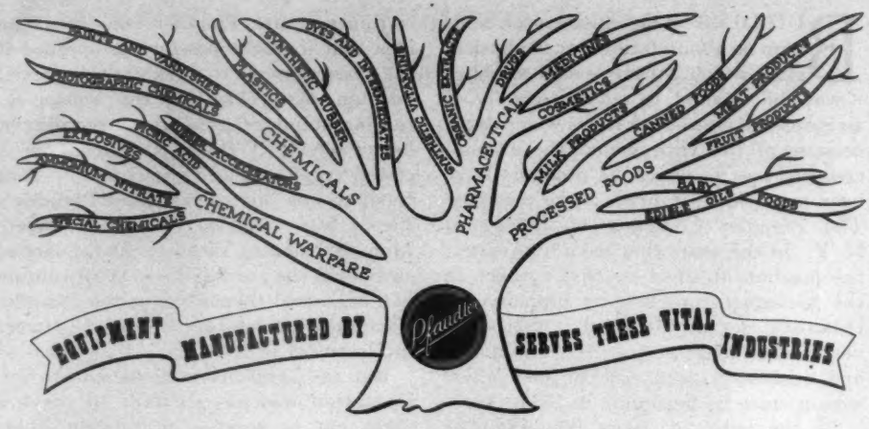
Today, both vacuum and pressure per-



LATE-MODEL AIR COMPRESSOR

The largest and newest of five Ingersoll-Rand air compressors that serve the Rochester plant.





THE PFAUDLER PRODUCTS TREE

form distinctive functions in Pfaudler apparatus, and so does the glass lining that characterizes certain of its products. However, since stainless steel became commercially available, the protective glass is required only when corrosive acids have to be guarded against. When that is the case, the equipment is made of low-carbon steel and lined with Pfaudler glass that has been developed progressively to meet the diversified conditions imposed by ever-widening fields of service. A Pfaudler glass lining will resist the corrosive action of all acids save hydrofluoric acid, which is destructive to glasses of all kinds.

In the course of the years, the company has found it necessary to increase the volume and the variety of its output in order to meet continually growing demands. In 1924, the Elyria Enameled Products Company of Elyria, Ohio, which had already won an enviable reputation for itself with its line of enameled dairy and chemical equipment, was merged with The Pfaudler Company and is now known as the Elyria Division. A British branch—Enameled Metal Products Corporation—was established in 1933 with a factory at Leven, Fife, Scotland; and before the second world war Pfaudler had a plant operating at Schwetzingen, Baden, Germany. With all these facilities at its command, the company was recognized as the largest producer of glass-lined steel equipment, and today its apparatus are in use well-nigh the world over.

Although the manufacture of glass-lined tanks was the dominant activity for years, and tanks big and small are now turned out in large numbers, this product is but one of many made by the concern. It has been said: "Pfaudler enamel is looked upon as the world's best," but this eminence might not have been reached except for the fact that the company has always relied upon intensive research. Both the Rochester plant and the Elyria Division have research organizations that operate independently but collaborate for the good of all the factories, here and abroad. The laboratories deal with every technical problem, new developments, and modifications that will keep apparatus in step with changing needs and, being in a way competitive, are stimulating and keep their workers "on their toes."

The terms "tank and equipment" embrace many widely differing products which are likely to entail some differences in construction or in associate features. In one case the container may be a simple storage tank, in another it may be a complicated reaction kettle or part of a distillation assembly. Again, a typically modern vacuum pan may be utilized for cooking fruits or vegetables in the presence of a minimum of air, or it may serve other essential purposes. The brewing industry and, later, the dairy industry, were Pfaudler's principal customers for years, and along in 1910 the company brought out the first glass-lined tank cars and truck tanks for the transportation of bulk milk over long runs.

Having proved satisfactory, similar facilities were later used for the carriage of liquid sugar, glucose, wine, and other fluids. Tanks of this type are now built of stainless steel when the commodity is noncorrosive, but if it is of a nature that will attack a bare metal surface then, as has already been mentioned, glass linings on low-carbon steel are required. They have capacities ranging from 500 to 3500 gallons, and certain of them such as milk trucks are insulated with cork. While in transit, they will hold their contents for fully sixteen hours with a rise in temperature of less than 2°F. This characteristic makes it possible for them to pick up their loads from very widespread "milk sheds" and to deliver them in a fresh condition at terminal plants for processing and local distribution.

A graphic idea of the extent to which Pfaudler now contributes to the nation's many industrial departments is given by the accompanying "tree," with its branches stemming from a source that is more or less allied with chemistry. The final products must be chemically pure to meet modern standards, and the apparatus utilized in achieving this end must be adaptable and susceptible of precise control. Such are some of the changes that the years have wrought since the company turned out its first glass-lined vacuum tanks for the brewing of beer—a modest but momentous development. The effect of that innovation may be likened to the pebble thrown into a placid mill pond—the ripples induced continuing afterward in ever-widening circles.

While there is no desire to harp on what happened during the recent war years, still the fact remains that the diversified calls for industrial coöperation led to technological and productive achievements that would normally have come to pass over a far longer period. The impress of this advance is strikingly evident in some of the amazing things that were done during that time in answer to our needs and those of other nations. Take just three of them: the making of penicillin, blood plasma, and the wonderful sulfa drugs for saving the wounded.

Twenty large concerns were marshaled to supply us with penicillin, and to do so they had to be provided with glass-lined steel fermenters, process kettles, distillation equipment, solvent-recovery assemblies, and other special apparatus of the Pfaudler type. We cannot describe here how penicillin is made, nor detail the numerous and exacting steps that must be taken to turn out a product of the necessary grade. But it is suggestive of the work involved to be told that as many as 10 gallons of culture fluid are required for a single gram of pure penicillin. (A gram is equivalent to 15.4 grains.) By the spring of 1945, the plants engaged in this urgent work were producing this miraculous substance at the rate of about 400 billion Oxford units monthly, or enough to treat a million cases. To do this, nearly two million gallons of culture had to be processed every 30 days. At first, the cost of making 20 cubic centimeters of penicillin was $100—the vial containing 100,000 Oxford units. Early last year, the cost for that small quantity had dropped to $2, thanks to better technique and control, with the prospect of still greater economies.

At the high tide of conflict, the American Red Cross was asked to maintain a steady supply of two million pints of human blood a month. One pint when processed yielded a pint of plasma solution, as used in the first half of 1942, and often 4 pints were needed to save a life on the battlefield. But the urge to save weight and space in transportation led a group in the Harvard Medical School to discover how to produce plasma by fractionation and so break down blood into its various components. The outcome was plasma concentrate—processed in glass-lined equipment—that served the purpose while occupying only one-fifth as much space as whole plasma.

Of kindred importance have been the sulfa drugs which, like the upraised hand of the traffic cop, have been the means of

halting the advance of infection induced by the so-called "strep germs." These drugs have been of the utmost value in wartime, particularly in the casualty clearing stations. Certain of them are virtually specifics in combating pneumonia and other germ diseases. In their production, as well as in the laboratory and in the pilot plant that precedes quantity output, Pfaudler apparatus and equipment are extensively utilized because they safeguard the materials at every step from actions that would harm them and render them unfit to be marked "CP"—chemically pure.

In this connection we should not forget that the welfare of our civilian population of more than 140 million is intimately related to what is done for them by the chemical, pharmaceutical, and processed-food branches of our industries. Synthetic rubber and materials of many kinds served their special purposes during the grim years lately ended, and will continue to contribute to our comfort and convenience. Synthetic vitamins are publicized so widely and used so broadly that most of us know about them but have little if any knowledge of how they are made. In 1925 the wholesale value of our vitamin output was given as $343,000; the retail value of our 1942 sales was reported as $130,896,000; and war needs brought up production to an estimated $200,000,000 annually.

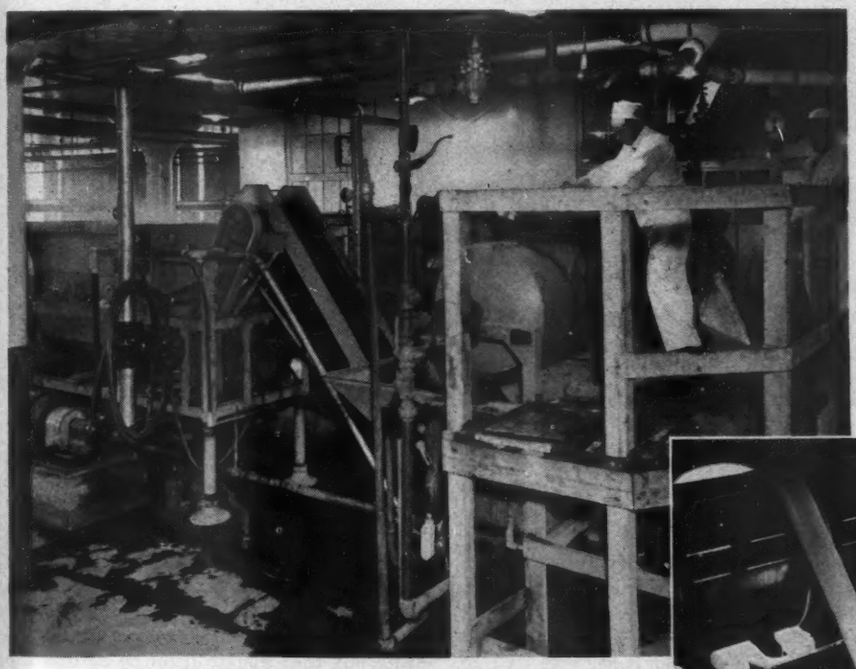
By the direction of the Government, many millions of pounds of flour were enriched by the addition of vitamins, and foods being sent abroad are reinforced in the same way to make even restricted allowances more effective in saving lives and in helping others in less critical condition back to physical well-being. Powdered milk is one of the commodities prepared in this country on a scale of more than 700 million pounds a year for foreign relief. This dried foodstuff, though made from skim milk, is rich in nutritive value. The economic significance of this lies in the fact that for a long while skim milk was not marketed but was generally classed as waste by dairymen if they did not use it for feeding farm stock. Pfaudler apparatus plays a prime part in providing us with all these commodities.

And now for some facts about the company's two plants in this country. The Elyria Division fabricates glass-lined steel, stainless-steel, and nickel-steel products of types usually needed by the chemical and food-processing industries. That establishment occupies a site of about eight acres, and the factory space under roof has an expanse of 70,000 square feet. The other plant covers an area of more than 46 acres on the outer limits of Rochester, N. Y., and the factory buildings have a floor space of about 390,000 square feet to meet a wide range of manufacturing requirements that have broadened considerably in scope during the last few years. A large new section, built during 1938, was planned and equipped especially for the construction of tanks 40 feet or more in length and up to 12 feet in diameter. The furnaces installed there for the enameling process are big enough to handle any of them and are provided with pyrometers and automatic temperature controls that assure conditions precisely in accordance with process needs.

Many of the capacious tanks turned out during the war were essential to the various synthetic-rubber plants, as well as to those engaged in the manufacture of high-octane aviation gasoline involving operating conditions that are damaging to unprotected metal surfaces. In a plant producing butadiene there is as much as 8500 feet of jacketed and unjacketed glass-lined pipe in the make-up of the heat exchangers because the product handled is corrosive and exposes the apparatus to strong sulphuric acid, hydrocarbons, and tertiary butyl alcohol at temperatures up to 250°F. and a pressure of 150 pounds per square inch.

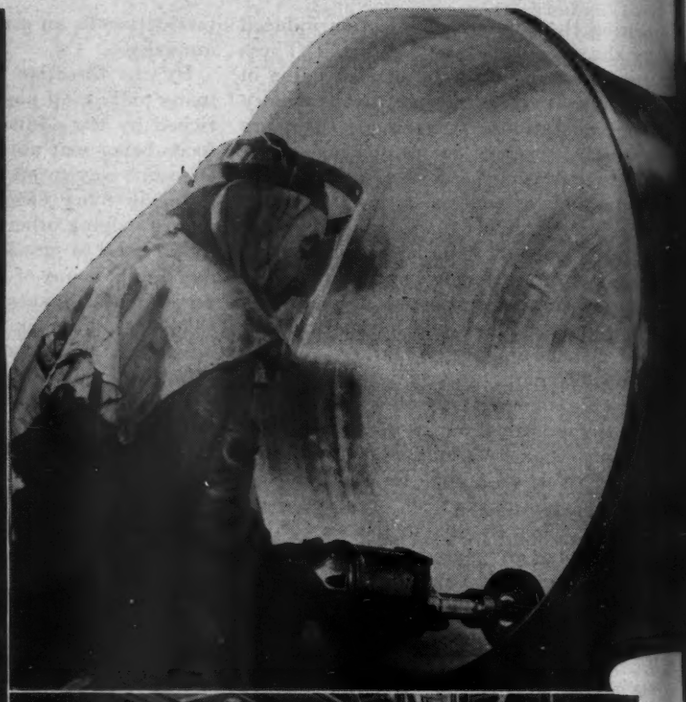
The construction of a glass-lined tank starts with the shearing of low-carbon steel plates made by the open-hearth process to exacting specifications. After cutting, the plate is rolled to a given diameter, the heads are pressed, and then the shells, heads, and jackets are welded together. How the latter work is done is of the utmost importance, and it may be said that The Pfaudler Company was among the first in this country to build welded vessels. Today, it depends principally upon the latest approved electric-welding facilities.

Inside welds are ground smooth before a tank is lifted and shifted by traveling cranes to the steel-grit or sandblasting department, where the inner surface is prepared for the application of the glass



UNUSUAL APPLICATIONS

The apparatus pictured above is a mechanical peeler of potatoes and other root crops. The vegetables are treated with steam under pressure and their loosened jackets are then removed with jets of wa'er. One unit can peel up to 5000 potatoes an hour. The U. S. Army has recently used large amounts of Aralac, a synthetic wool that is made from skim milk. Much of its preliminary treatment takes place in Pfaudler glass-lined equipment. The view at the right shows some of the material after it has been forced through spinnerets while in plastic form.



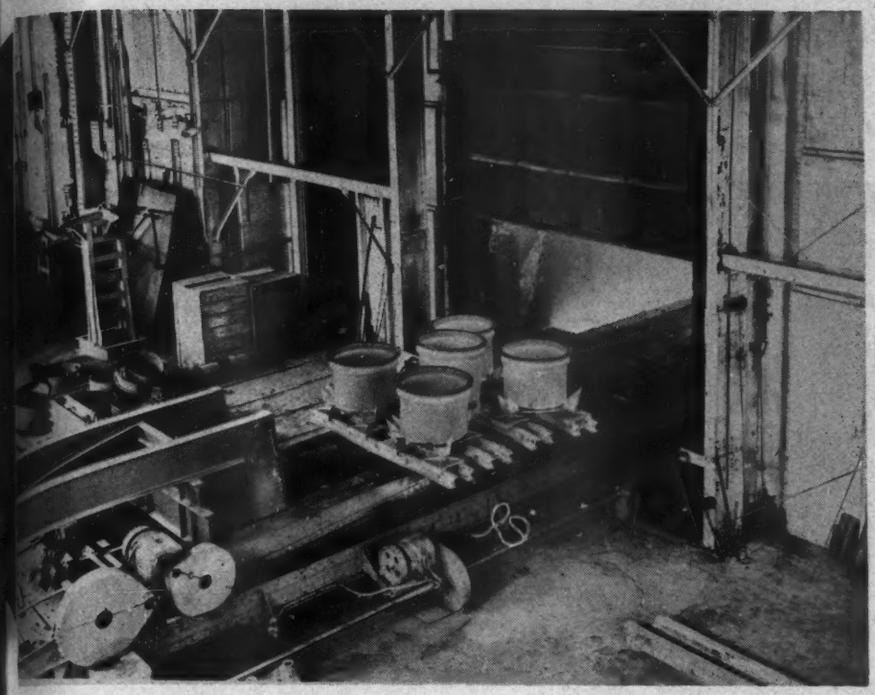
lining. This division consists of four separate sections or compartments which accommodate the largest of the tanks produced. The sandblasting apparatus is of the Pangborn type, and the work demands large volumes of compressed air. In fact, compressed air is widely used for many purposes and is furnished by five Ingersoll-Rand units of varying capacities.

Before describing how the glass lining is applied, some facts about Pfaudler acid-resisting, hard, blue glass are in order. This material is unaffected by thermal changes and is markedly resistant to mechanical shock. According to the technicist, "Pfaudler glass is a borosilicate that is combined with the backing strength of steel." As to what it represents as a gradual development over the years, we have this authoritative statement from experts of the Rochester organization: "Many exceptional products of this type have been developed, but to our knowledge none is resistant to the halogen acids and other active mineral acids in any degree approximating the resistivity present in Pfaudler acid-resisting glasses."

The carefully proportioned ingredients are fused, and when the glass is in a molten state it is dropped into water where it is solidified and at the same time minutely fractured by chilling. The resultant product is known as "frit" and is placed in a battery of ball mills where it is pulverized and acquires the form of a sky-blue powder which, when wet, is the "slip" that is sprayed on the metal surface with the aid of a pneumatically operated pistol. This is done in air-conditioned chambers from which excess dust and particles are removed. After drying thoroughly, the vessel is moved on a car or platform to a gas or oil-fired furnace into which it is shoved by a charging machine. The furnaces operate at a temperature range of 1700 to 2000°F., and firing of from ten to twenty minutes fuses the glass on to the prepared steel surface. The first film is known as the ground coat, and two or more additional ones may be similarly laid on with a pneumatic pistol, dried, and successively fired in the furnace. The number of coats varies with the protective requirement of the glass lining—that is, with the corrosive action of the acids to which it may be exposed.

All Pfaudler glass linings are of a minimum thinness agreeably to the service expected of them, and each is held to its supporting steel base by a bond of adhesion of about 3000 pounds per square inch, minimum. Thinness of the glass film is one means of promoting essential heat transfer between the steel wall of a vessel and the contents of that vessel, for where heat is applied for cooking or processing it is highly desirable that there shall be no local concentration of thermal units but that distribution be as uniform as possible. Pfaudler glass-coated agitators maintain a smooth flow or movement of the contents to obviate "hot spots," and they assure this circulation without any churning action that may cause cavitation. Depending upon the type of glass and to what it may be subjected, the approximate life may range all the way from 2 to 244 years!

Pfaudler glass-lined vacuum cookers and preheaters are extensively used indus-



MANUFACTURING OPERATIONS

The starting point in the production of most tanks and similar vessels is cutting the sheet metal to the desired pattern. At the extreme left is shown an operator shearing a sheet of stainless steel. The workman in the next picture at the top is removing all traces of welds from the inside of a kettle with a pneumatic grinder and at the same time polishing the surface to what is known as an "80-grit" finish. Before a container is lined with glass its inner walls are sandblasted to provide a favorable surface for a tight bond between the two materials. The large tank in the bottom picture is being shoved into a blasting chamber. Vessels are glass lined by spraying on "slip" in successive layers, and each coat is fused to the steel by heat. At the left are 100-gallon vats just after emerging from a fusing furnace.

trially in making preserves and jams from fresh and cold-pack fruits. Preliminary cooking is done in jacketed glass-lined preheaters, from which the still raw materials are drawn into vacuum pans for final cooking. By this process most of the preserving is done at a temperature not exceeding 135°F. instead of at 220° and higher, as is the case with open kettles. Vacuum-cooked products are definitely superior in flavor, and in a well-equipped plant the output is greater than by the open-kettle method. The saving in labor is said to be around 50 percent, and operating costs are much reduced.

Among the manifold apparatus manufactured by The Pfaudler Company are glass-lined calandria-type steel evaporators which have many applications in some branches of the food-processing industry. They can be used, for instance, in making tomato puree or tomato paste. In the case of the latter, the juice is drawn into a glass-lined evaporator by vacuum—3500 gallons per batch, which is processed in from 1 to 1¼ hours. The final concentrate, depending upon the density desired, will carry from 26 to 30 percent solids. The vacuum maintained ranges from 26½ to 27 inches, and the steam pressure in the calandria varies from 3 to 5 pounds, while concentration can be effected at 135°F.

The glass-lined Prevak percolator, which utilizes pressure and vacuum in succession, is a Pfaudler unit that has been employed with notable success in the production of vanilla extract. The chopped beans are placed in a basket which is set in the upper part of the percolator where they serve as a filter bed hrough which the grain-alcohol solvent and water are forced under pressure, stimulated by the aid of vacuum maintained in the lower section of the apparatus. The temperature within the percolator is that of the room in which the work is carried on. In the case of one manufacturer, the president of the company said: "It takes about 48 hours to make a batch of pure vanilla; previously, with other methods, it took us from three to four days."

Glass-lined digesters, designed and built by Pfaudler, are helping to prepare foodstuffs of high nutritive value and purity for the infant population of this country. The vegetables and fruits are scrupulously inspected upon arrival at the processing plant. After cleansing, they are peeled, cut up, and delivered to sanitary hoppers for discharge into the digesters. The amount of material and the quantity of water placed in them vary with the products undergoing processing. Just before charging, any oxygen present in the apparatus is blown out with live steam, and immediately after charging the cover is quickly clamped shut. The fruits and vegetables are cooked under pressure no longer than necessary to soften them, speed enhancing their taste. Straining follows cooking, and then the foods are pumped into glass-lined vacuum pans where the moisture content is evaporated to a point to give each one the proper standard of consistency. Full vacuum is maintained, and the antiscorbutic vitamin content remains unchanged in consequence. It is said that the color of the final product compares with the color of the natural pulp and so increases appeal to the eye of the purchaser and, perhaps, to the child.

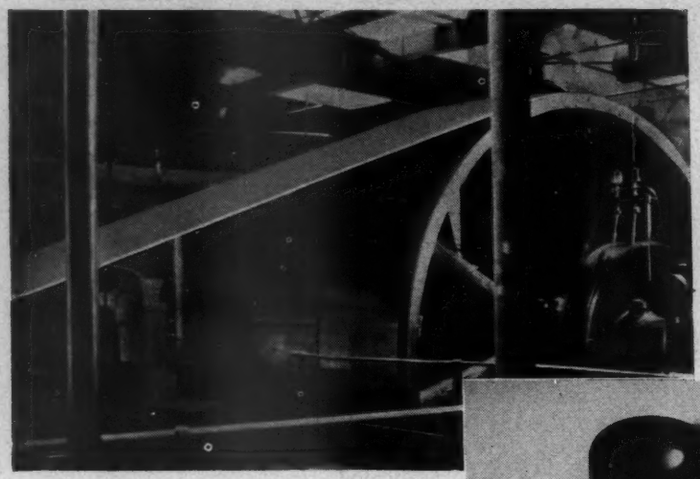
One of the newer of the company's products is a steam-and-water peeler for potatoes, beets, carrots, and other root vegetables. One of these machines will pare 5000 pounds of potatoes an hour and needs but one operator to handle it. The tubers are first dropped into a retort and subjected to about 80 pounds steam pressure during four revolutions—the heat penetrating approximately 3/16 inch the while. This virtually removes the skin and makes it much easier later for inspectors to cut out the eyes or other defects. From the retort the potatoes fall into a hopper, whence they are carried up a chute to the washer section where they pass over a series of rubber-covered rollers that run at different speeds and cause the potatoes to gyrate. As they are pushed forward by mechanical fingers they are exposed to a steady water spray issuing from nozzles at a pressure varying from 50 to 75 pounds—the force of the spray sufficing to remove all remaining skin. In one large dehydrating plant in Maine, this method of peeling potatoes has appreciably increased production per employee; and discoloration, usually very troublesome in preparing them for processing, has been well-nigh eliminated. Dehydration of vegetables was essential during the war and is still playing its part in carrying on relief work in stricken countries. The improvements that have been made in this department of food preservation—apart from weight and space saving—may bring about its wide application in normal times.

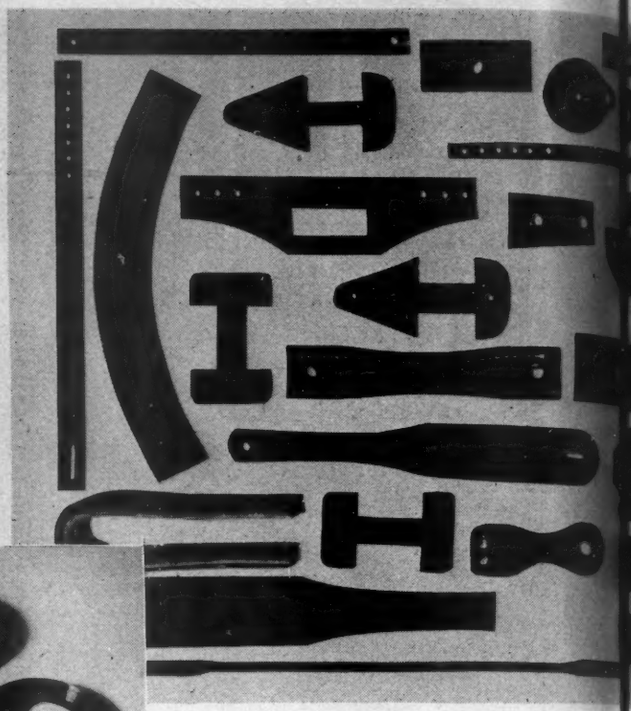
In many respects, much that is done in the Rochester plant is also done in the smaller Elyria Division, thanks to qualified craftsmen and fabricators. As the company itself says: "Pfaudler has built up an experience few fabricators possess. This covers the fabrication of various materials of construction such as glass-lined steel, stainless steels, nickel alloys, and clad materials, all of which have specific characteristics with reference to corrosion resistance, heat transfer, workability—all important in delivering equipment that solves specific problems." And through its 60 years of experience Pfaudler engineers, metallurgists, ceramists, and welding experts have added to the value of what the workmen in the shops build.

The Story of Leather

Part 2

J. Edgar Rhoads





MENTION was made in the previous installment of this article of sales of sheepskin and hogskin by one of my ancestors to Abraham Lincoln, the great uncle of the president, in 1733. As Lincoln had an iron furnace and forge in the Schuylkill Valley, it seems likely that the leather was intended for a bellows to blow air into the furnace, This is probably the first entry in our old family account book of transactions in leather for use on what was really a machine. There must have been earlier applications of that character in the United States because furnaces were operating near Natick in eastern Massachusetts a number of years before that time. At least one of them belonged to the father of the Abraham Lincoln mentioned above.

Some of the hand looms of that day had leather "harness," meaning the various kinds of straps, etc., that held the moving parts and controlled their motions. After more than 200 years, modern high-speed looms still have leather straps and some of them require as many as 18 or 20. Numerous large concerns use them in preference to substitute materials even though their first cost is somewhat higher.

Hundreds, if not thousands, of years ago in Egypt, and possibly in other countries near the Mediterranean, water was lifted from streams or ponds for irrigation and household purposes by skins on slowly turning bucket wheels (*noria* or *sakieh*). Other means of lifting water such as pumps on early fire engines and hydraulic rams had leather washers, clapper valves, check valves, etc. In colonial times, thongs, straps, bands, and "aprons" were made of animal hides for many American industries, including flour mills, and for agricultural implements like flails and wooden rakes.

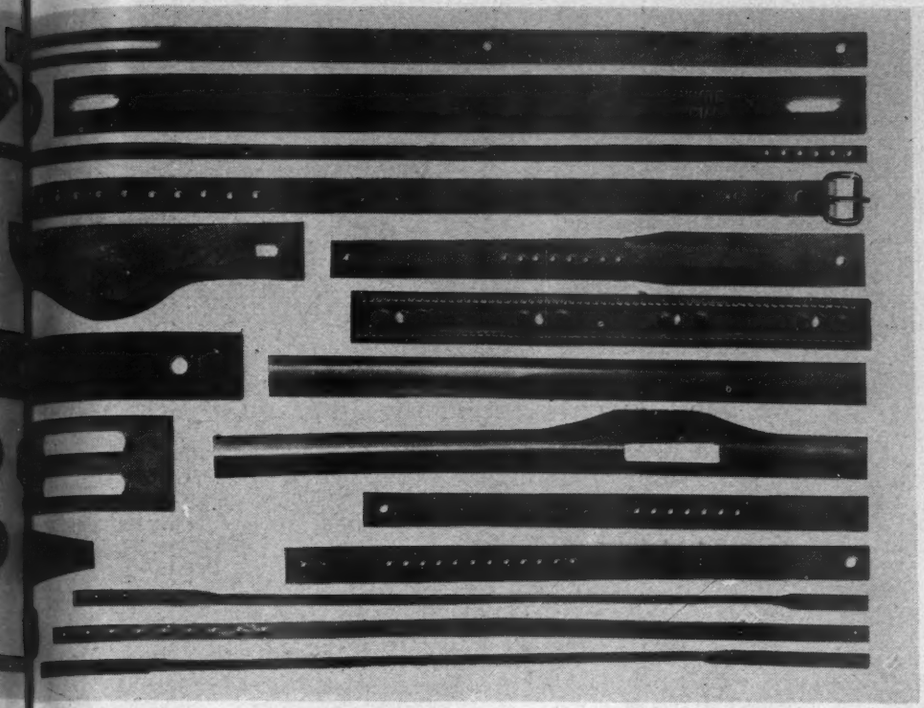
In addition to these "mechanical" applications of leather, our colonies used water buckets and water hose of that material before and even after the Revolution; and the bodies of some of the coaches, instead of being supported on springs, were carried on slings of 2- or 3-ply heavy leather that were akin to the traces of the harness which served to draw them. Examples of early American equipment, tools, and utensils of which leather constitutes an important part are to be found in many of our museums.

Today, probably more leather finished for mechanical application goes into leather belting than into any other product of that nature, though substantial amounts are required for packings, washers, and straps of many kinds. There is hardly an industry that does not need some of them. Users, to list but a few, are: mines, iron and steel mills, metal-working shops, machinery plants, and petroleum, paper, textile, and chemical industries.

The writer knew an old gentleman—head for many years of a large concern in which he had grown up and which he had largely developed—who, as a boy of seventeen in 1852, made bands or leather belts which served much as belts do now to transmit power from one rotating shaft to another or to a pulley on a machine such as a loom. The firm in question began to apply this method of power transmission sometime between 1840 and 1850. The lad simply took a "side" of tanned leather (half a hide) and cut it up into strips of the desired width. As the plant had no means of making a good lap, or properly tapering the ends, the latter were held together with copper rivets. A belt of the right length was put around two pulleys and probably ran at a rather low rate of speed so as to transmit the torque from the driving shaft to the driven shaft or machine. Before many years, according to the writer's informant, they had learned to make tapered joints or laps with glue; but even then the belts were rather crude affairs as compared with those of the present day which are designed to carry large amounts of power with efficiency and at high speeds.

Because much machinery vital to industry is still supplied with power through the medium of leather belts, a brief outline of the principal developments in their manufacture since those early days may be of interest. Belting leather was made for decades by the oak-bark method of tanning. This was a very slow process, taking about twelve months. After tanning, the hide was coated while still damp on the inner or flesh side with "dubbing," a preparation compounded of tallow and neat's-foot or cod oil. The grain, or hair side, was usually coated with oil alone.

After being piled down for a few days, the leather was hung to dry slowly without stretching. In about a week or ten days it was taken down, brushed by hand, and worked on a heavy table with a "slicker"—a thin piece of steel like a carpenter's scraper. The sides were then ready to be cut into perfectly straight strips of any desired width and having



LEATHER IN INDUSTRIES

Early hand looms used straps and other shapes of leather, and the textile industry continues to employ large quantities of that material. At the left are shown 36 different kinds of straps and other appliances for cotton looms. Substantial amounts of leather go into packings for hydraulic and other machines and several types of these are illustrated in the small cut. The greatest single application of leather in industry is belting the quality of which has been steadily improved through research and experience. Specially tanned belts have compiled remarkable records of durability and efficient performance, some of them having run six million miles at speeds of around a mile a minute. At the extreme left is part of a 76-inch-wide, 4-ply belt that transmitted power from a 2500-hp. engine in a paper mill for 9½ years until retired by changes in the set-up. It was repurchased by the manufacturer, cut down to 50-inch width, and since then has run eleven years in a lumber mill.

ends tapered into a wedge-shaped lap. This was done entirely by hand. The workmen used a spoke shave, a knife, and a slicker with the sharp edge bent over at right angles. When this was done carefully the slicker became a highly effective tool for fine cutting or scraping. The tapered laps were perfect wedges, and if one was cut from the grain side and the other from the flesh side it was possible to obtain a strong even joint with something like furniture glue. Belts of good size, up to 3 or more feet wide, were made by these relatively crude methods, and some on low-speed steam-engine drives are known to have lasted more than 50 years. A record of 80-odd years was reported for one at a mill in Philadelphia, Pa.

In the 1890's, many improvements were made in machinery for working leather of this type. Among these was a better way of applying grease—of spreading it more evenly—thus giving the material greater flexibility and decreasing internal friction. This was effected by "milling" the leather with grease in large heated drums. Other equipment was developed to provide flatter leather and to shave off the "flesh" on the inside more smoothly than could be done by former methods.

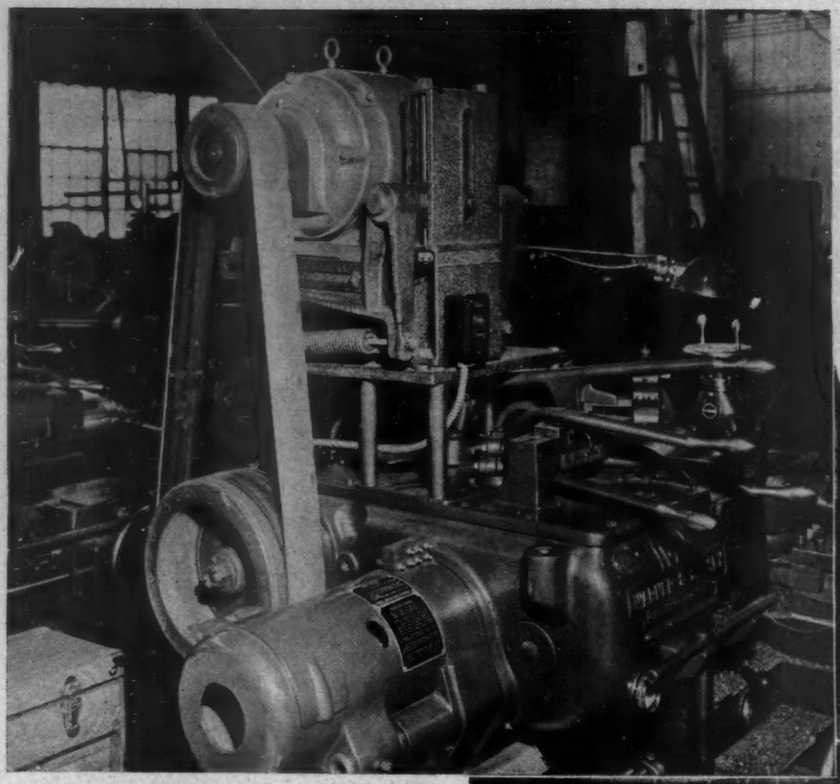
It should be noted here that leather belts of the early days were all 1-ply thick; but when the properties of glue became better known, and means became available by which heavy pressure could be applied to the laps to bind them together, then manufacturers began to turn out belts of two or more plies. These were joined so that the laps were stepped or "broken"—so that they would not come opposite one another. This was a great advance in the industry, for it not only increased the strength and capacity of a belt but also decreased its stretch and made it more true-running.

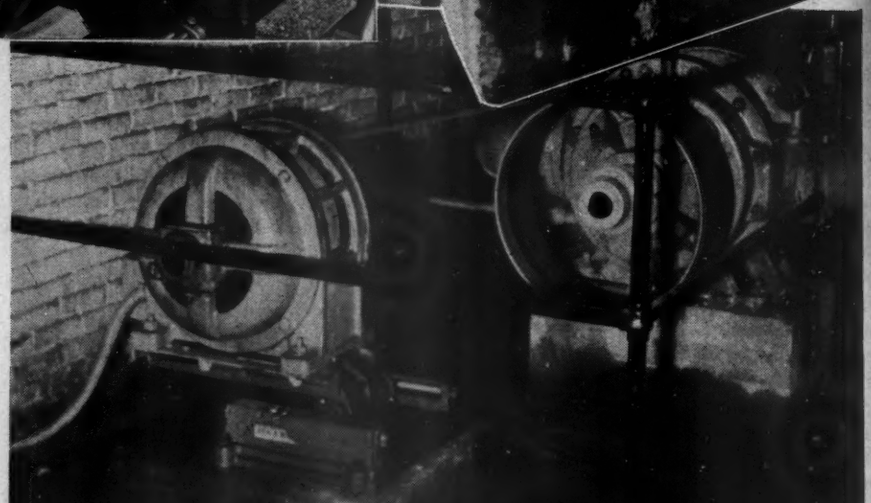
To glue the plies together, the surface had to be thoroughly cleaned so that the adhesive would have a good chance to adhere well. The new shaving machines made a far better job of this than the old hand method using another kind of long knife with turned edges. Soon after this equipment had been designed, heavy machines for stretching leather after greasing and before drying were put into service. These were essentially frames with jaws by which both ends of a long piece could be clamped securely. One of these jaws was arranged to slide on a piece of timber so that it could be pulled out and fastened in a way to put heavy tension on the material. The stretching frame was then set aside for several days to allow the leather to dry. With that done, it was removed and cut into strips for belting. By this process it was possible to give a belt the major part of the stretch that it would normally have developed only during use. Obviously, all these improvements tended to increase the efficiency and usefulness of belting, enabling it to run at higher speeds and to take heavy loads satisfactorily.

Up to this time there had been little application of science to the manufacture of leather—not much consideration had been given to the basic properties that would make it perform best as belting. In the beginning of this century, various workers experimented with other than the traditional oak-bark method of tanning because they believed that something better than oak leather could be found. They learned that some types of lighter leather could best be tanned by using chromium salts and by lubricating the fibers later with "fat-liquor" made of soap and oil.

Chrome-tanned leather had a higher coefficient of friction than leather tanned with oak bark. It had excellent strength when new but was inclined to be somewhat erratic in performance, particularly in the matter of stretch. It was not satisfactorily stable in the presence of certain chemicals like dilute sulphuric acid to which it might be subjected in some industries. A few of the larger companies undertook research work to overcome these difficulties. Tests were made to determine the physical and chemical properties needed to retain high strength with little stretch and to give greater coefficient of friction. It was realized that low internal friction was important, as well as resistance to machine oil, water, and certain chemical fumes such as those of ammonia, sulphur dioxide, and others. In addition, belts were required to withstand a fairly wide range of temperatures because they sometimes have to drive under subzero weather conditions and, again, in dry ovens or other places where they may be exposed to 200°F. and more.

As a result of these investigations, leather belting was developed that was about 50 percent stronger than the earlier product and that showed definite betterments in every other respect. Continued research in the three decades that have passed since that time has brought about many further improvements. Today, specially tanned belts are driving some of the most important machines in a wide range of industrial plants and have operated successfully for years transmitting hundreds of horsepower. One such drive from a large Corliss engine called for a belt 76 inches wide and 4 plies thick and took the centers from about 300 of the choicest steer hides. The installation tension of that belt was 30,000 pounds, and it carried the full load, 2500 hp., which other types had failed to do.





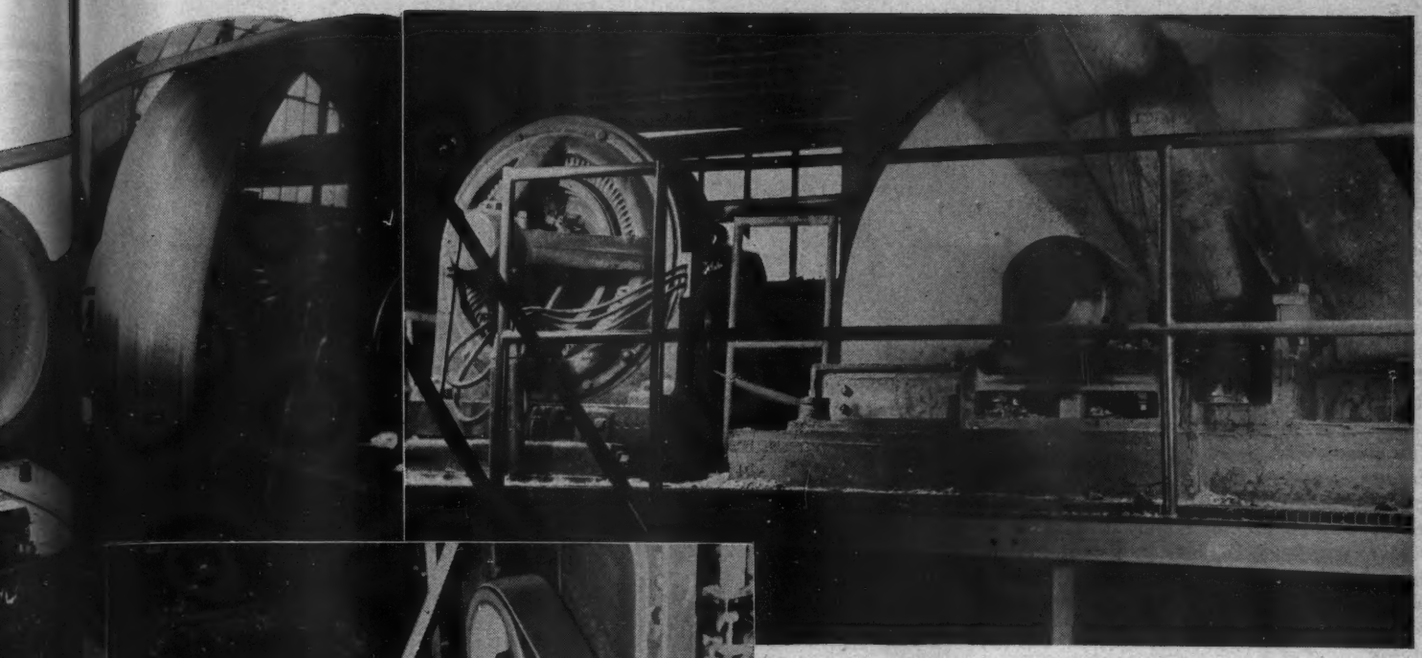
During World War II, mechanical leathers played a vital part in helping to turn out many essential products, so much so in fact that this branch of the industry was allocated substantially all the leather it needed when that commodity was extremely scarce. Besides leather for belting, the material was in great demand for hydraulic packings for gun mounts and valves for dry docks, as well as for presses with a capacity of many hundreds of tons, pumps in oil fields, and controls for machinery and airplane equipment, to mention only some of their more interesting applications. Certain machines require friction or clutch bands to start and stop them, or to regulate the speed of some of their movements. Others need washers or seals at points where leather has proved to be especially effective. For all these purposes, as for belting, reliability is one of the factors that govern the choice of material.

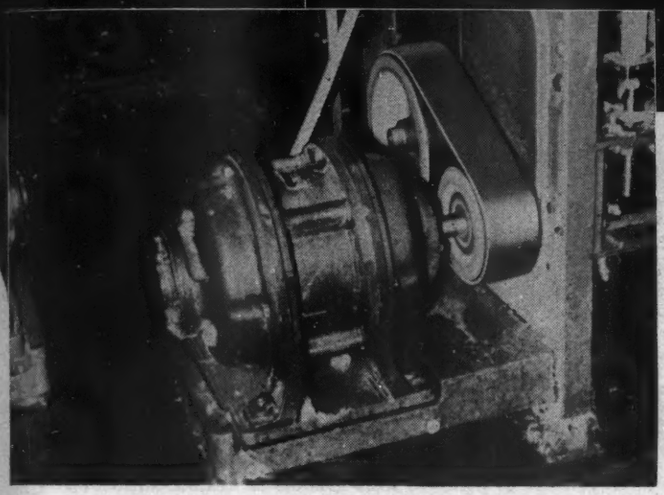
Substantial amounts of mechanical leathers are used in the various branches of the textile industry. As has already been mentioned, there are many different kinds of straps on looms, including check straps, lug straps, harness straps, and jack straps; also tiny calfskin cots for drawing fine yarns; large "aprons" of several types made from heavy steer hides for worsted- and woolen-mill machinery; leather backing for card clothing which serves to parallel the fibers of cotton or other raw materials.

In the case of a belt, the stresses to which it is subjected are chiefly induced by tension (the tension under which it is applied, the tension attributable to the work it has to do, and the tension due to centrifugal force), flexing under tension, and drag on the surface as the belt receives or imparts force from or to a pulley. In the case of hydraulic packings there is friction on the surfaces, but most of the other stress is caused by the pressure of the fluid on the packing, forcing the latter against the moving plunger or cylinder wall. However, the most suitable leather for both belting and packings is one that is very strong. Packings must resist tearing under high pressure, which often reaches 10,000 pounds per square inch, sometimes several times that much.

As with belting, the leather component of a machine usually represents but a small part of the total cost but is a very vital link in the production chain. For example, a hydraulic press involving an expenditure of more than $10,000 may have packing costing only a fraction of 1 percent of that amount, not including its installation, which may cost many times as much as the packing. At a paper mill or steel plant, drive failure may entail a loss of several hundred dollars an hour. Management can therefore ill afford to use anything but the very best of equipment—the best being the cheapest in the long run even though the first cost is high.

Many factories operating 24 hours a day seven days a week find that leather-belt drive is reliable and efficient. One report about such drives that has come to the writer's attention concerns some 30 large fans in a chemical plant. These units exhaust noxious fumes and had been running 364 days a year for more than





PIVOTED BASES FOR MOTOR BELT DRIVES

During the past fifteen years the efficiency of flat belt drives for services involving the transmission of more than 5 hp. has been greatly improved through the development of pivoted motor bases that automatically maintain correct belt tension. Thousands of assemblies of this type were used to operate essential machines during the war period. The pictures show various set-ups of this driving method, and it will be noted that most of them illustrate short-center applications. Where the motor is placed above the driven machine (extreme left), springs actuate the pivoted base so as to maintain proper tension. In other instances tension is maintained by the weight of the motor alone or in conjunction with the motor torque. When correctly designed and set up, installations of this kind operate with little attention for years.

eight years with never a stop and virtually no maintenance. During that period the belts had traveled from about three million to four million miles, the difference being attributable to the individual speeds of the drives. They are still in service. The maximum capacity of the motors is 150 hp. Few types of mechanical equipment can show such a performance record. There are other leather belts in use at the present time which have run more than six million miles at speeds close to a mile a minute.

Most industries have belt drives from motor to machine or from motor to shaft which, in its turn, operates several machines (group drive). One way or the other, a type must be installed that will function even with large pulley ratios and often on shaft centers little if any greater than the diameter of the largest pulley. Various rigid drives such as chains, gears, or speed reducers are in use. Under certain conditions these work well, under others a nonrigid or nonpositive type is safer in case something jams in a machine. Usually, the latter drive is also lower both in first cost and in cost per year, and may be more efficient. Rubber or leather "V" belts are extensively utilized with drives of this class. These belts are wider at the top, and the sides, which generally have a slope of about 15°, tend to wedge into a corresponding groove in the pulleys. This type of drive is very good for single-strand application such as automobile-fan and generator belts and for small motors.

For about fifteen years, however, there has been a better method, particularly for service where upwards of 5 hp. is used. It represents a great step forward from fixed centers between shafts, or even sliding-rail bases for motors, for with it it is a relatively simple matter to set a motor to drive a shaft or machine even on very short centers and with a fluctuating load and still have correct tension on the belt at all times and for all loads.

This method involves the use of a pivoted base on which the motor is mounted. The position of the latter can be adjusted in relation to the pivot point and the driven shaft to get proper tension. Center distance and alignment also can be adjusted readily if required. Flat pulleys and a flat leather belt are usually employed and give extra-good results when they are made for such drive conditions. The tension on the belt is automatically maintained by the weight of the motor. In some installations that is accomplished by a combination of motor torque and motor weight; in others, where the motor is placed above the machine, a pivoted base actuated by springs serves to control the tension. Accompanying illustrations show typical installations.

When properly designed and set up, units of this type are extremely efficient and operate for years with little maintenance. Many have run more than five years with no replacement of belts, some much longer. Improper setting will, of course, reduce efficiency and shorten the service life of a belt. Thousands of pivoted-motor-base drives up to 500 hp. have been used during the war to operate machines doing highly essential work in chemical, textile, steel, metal-working, and many other plants. Their contribution to industrial production has been and is substantial. There is every indication that drives of this class will play a still more important part as more and more industries turn to them because they have been tested under the severest kind of conditions and not been found wanting. For these, too, "there is still nothing like leather."

Suits for High Fliers

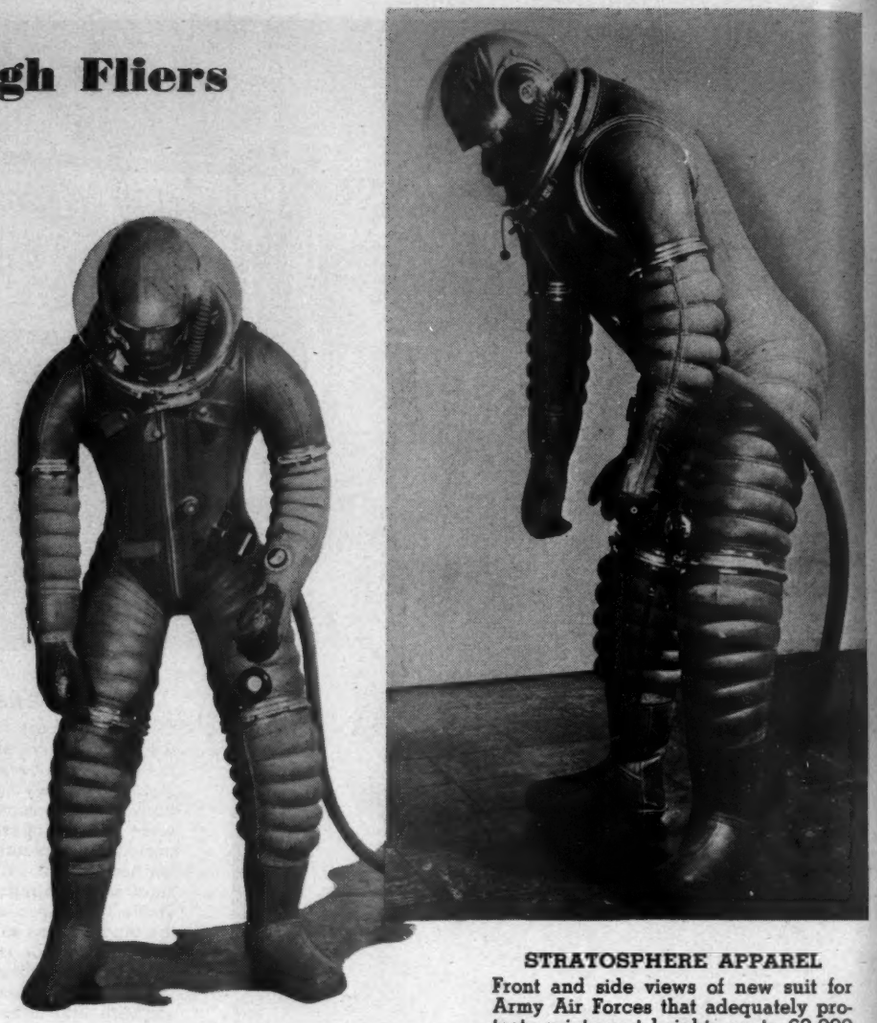
ANOTHER wartime secret has recently been disclosed by the Army Air Forces in showing to the public what is known as the "Inverted Fish Bowl" pressure suit that has been developed for stratosphere flying. To the casual eye, the garb is strikingly suggestive of the fanciful illustrations that have appeared from time to time of "The man from Mars."

Most of us have some knowledge of how Nature has seemingly designed that human beings should live more or less close to sea level or within an atmospheric range limited to less than 16,000 feet above sea level. Also, it is common knowledge that artificial means must be provided to safeguard underwater workers, as well as airmen who engage in high flying.

For the diver there must always be maintained within his suit air pressure slightly in excess of the outlying hydrostatic pressure; and, after serving to inflate his suit and furnishing him with life-giving breath, that air is allowed to pass out into the water. Oppositely, in the case of the aviator, when atmospheric pressure drops below a definitely established minimum, it is necessary to house him either in a pressurized cabin or a pressurized suit and, to safeguard bodily functions, to supply him with sufficient and equally vital oxygen at proper pressure.

The needs of the man who flies above 35,000 feet, except when he does so for very brief intervals, are somewhat complex. Therefore, to meet the demands imposed upon him in combat service, special provisions have to be made to keep him mentally alert, physically fit, and bodily secure from the hazards to which he would be exposed by greatly reduced atmospheric pressure—a deficiency of oxygen at normal pressure—and the sapping effects of intense cold. In principle, the Army's pressure garment has been developed after long study and planning to meet all these requirements.

According to tests that have been conducted, the new suit would enable individual members of an aircraft built for stratosphere flying to ascend to an altitude of 62,000 feet and maintain the while near-normal pressure on their bodies. As has been officially stated, the suit "resembles a combined deep-sea diver's dress and a large gold-fish bowl. The low pressure at the high altitudes for which this suit was developed would result in certain death, for the internal pressure would rupture all blood vessels and inflate the human body until it burst. The pressurized suit counteracts the loss of external pressure, and allows mobility of the individual at near stratospheric heights." Above an altitude of 42,000 feet such a garment or cabin becomes essential.



STRATOSPHERE APPAREL

Front and side views of new suit for Army Air Forces that adequately protects aviators at heights up to 62,000 feet. The plastic head covering has given it the popular name of "Inverted Fish Bowl" suit. The remainder of the assembly is made mostly of rubber with metal joints that permit fairly free functioning of the arms and legs. Oxygen-rich atmosphere entering through the hose keeps the entire body under near-normal sea-level pressure and also supplies the wearer with breathing air.

As the accompanying photographs reveal, the suit is made mostly of rubber with metal joints. It is capable of being sealed airtight and affords a measure of freedom of movement. The transparent plastic globe, besides giving ample range of vision, is lightweight and yet strong enough to withstand the pressure of the artificial atmosphere provided for the wearer when he is obliged to isolate himself from the rarified exterior atmosphere. At that time he has to depend upon a supply of air that is made up principally of pure oxygen under regulated pressure and is fed through a rubber tube that acts as a closed circuit between the source of the air and the flier.

To the critical observer, the suit would seem to be somewhat clumsy and possibly too heavy, but no doubt it is a long step forward and will lead to further developments. The aim is a garment that, while giving the wearer greater freedom of action—less weight to carry, will yet assure his safety at stratospheric heights and temperatures and will not seriously hamper him if it becomes necessary for him to bail out at any time. At an altitude of 62,000 feet, which is nearly 11.75 miles high, the temperature is about 70° below zero Fahrenheit. The air pressure at 40,000 feet is around 2.75 pounds per square inch, as compared with 14.7 pounds at sea level, and above 40,000 feet the pressure of the rarified atmosphere drops lower and lower the higher the airman ascends.

As has been explained by Bryan H. C. Matthews, an eminent British physicist: "The human safety limit in height is some 10,000 to 16,000 feet breathing air, and 40,000 to 42,000 feet breathing oxygen; heights much in excess of the latter are only achieved by enclosing the pilot in an artificial atmosphere." It is just this that the experts of the Army Air Forces have done in devising the pressurized suit.

Railroads Mark Centenary of George Westinghouse's Birth

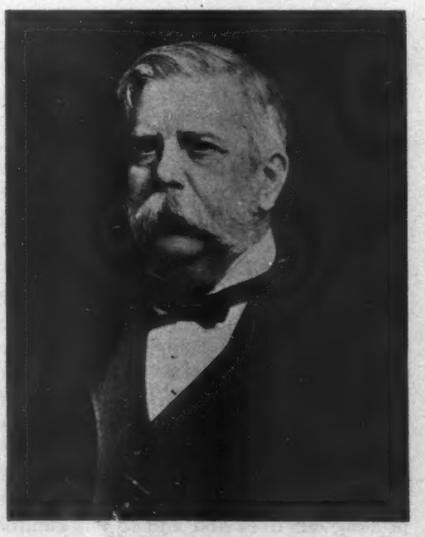
HONORING THE INVENTOR OF THE AIR BRAKE

On October 6, the centenary of the birth of George Westinghouse, J. J. Pelley, president of the Association of American Railroads, laid a wreath before the Westinghouse bust at the permanent exhibition of the air brake in the Smithsonian Institute, Washington, D. C. Acting on behalf of the nation's railroads, Mr. Pelley called the Westinghouse device one of the world's most significant inventions and stated that its successful demonstration in 1869 "revolutionized railroad transportation in the United States and throughout the world."

THE nation's railroads honored George Westinghouse for his invention of the air brake on October 6 at Washington, D. C., in simple ceremonies at the permanent air-brake exhibit that was placed in the Smithsonian Institute in 1941. The occasion was the one-hundredth anniversary of the birth of Mr. Westinghouse. A wreath was laid before his bust by John J. Pelley, president of the Association of American Railroads, who spoke briefly upon the significance of the air brake in promoting modern railroad transportation and in stimulating the development of the science of pneumatics.

"Railroad transportation throughout the world was revolutionized by the inventive genius of George Westinghouse and his air brake," Mr. Pelley stated. "The hundreds of thousands of men and women who work on the nation's railroads, and the hundreds of millions who are transported yearly, owe a debt of gratitude to Mr. Westinghouse which today we have humbly tried to express by paying tribute on the centennial anniversary of his birth. This exhibit accords to Mr. Westinghouse the recognition by science of the measure of the worth of his invention.

"I speak for all railroad men and women when I say that the American standard of living today—one unparalleled by any other nation in history—has been made possible to the largest degree only by this youth from Central Bridge, N. Y., who settled in Pittsburgh and there developed and demonstrated his invention for stopping trains; founded the Westinghouse Air Brake Company, the company that bears his name and that of his invention; and who, at the time of his death in 1914, had left his mark on many industries and had received innumerable honors from scientific societies and governments of many countries. A production genius, it was his first invention—that of the air brake—that brought him universal acclaim and elevated him into the charmed circle of the most significant inventors in the history of this country.



GEORGE WESTINGHOUSE

"The science of pneumatics and its application to almost every phase of our everyday life, owes its development to a youth not yet 23 years old who successfully thought through a method whereby air was placed under control and made to work for the human race. He did not simply find a method of bringing a moving train to a halt through the movement of a man's hand. He conferred upon the tools of transportation the freedom to go, and go fast, by giving these vehicles the power to stop. This made possible more rapid transportation, longer and longer trains, moving more frequently with heavier loads at higher speeds, and this with ever increasing safety."

George A. Blackmore, chairman of the board and chief executive officer of the Westinghouse Air Brake Company, said in part: "Mr. Westinghouse conceived the air brake 78 years ago for the purpose of making rail transportation safer. He had been appalled when he witnessed—near his boyhood home—two freight trains crash into each other in broad daylight on a smooth, level, straight stretch of track, despite efforts of the trainmen to halt them by applying hand-brakes.

"He tried and discarded steam and electricity as power sources for his brake. A chance reading of a magazine article, describing how engineers in Italy made use of compressed air to actuate drills, gave him his inspiration. He compressed air, and applied it as the motive power for his brake. From the day of its initial demonstration on a railroad train a new impetus was given to railroading, and gainful employment was created for hundreds of thousands in both industry and agriculture, not only in this country but abroad.

"Although Mr. Westinghouse conceived the air brake for the railroad, research and development also provided brakes for street railway cars, subway trains, high speed metropolitan transit lines and automotive vehicles, while the use of air controls, based on the theory behind the air brake, are in actual operation today on marine engines, huge earth-moving and other industrial machines. Pneumatic controls, all based upon the original invention, are used in industry in various ways and research still goes on with the men in the laboratories envisioning the time when entire factories will be made safer, and at the same time more productive, through compressed air controls patterned upon the device conceived by George Westinghouse."

Editorials

OUR PATENT SYSTEM

DURING the Middle Ages, the reigning monarchs of England assumed the authority to grant to favored individuals the exclusive right to manufacture or sell particular goods. The grants were made in the form of letters patent, and from that practice stems our patent system. Asserting this royal prerogative, the crown handed out monopolies as rewards for services rendered. Abuses of the privilege naturally arose, and during the reign of Queen Elizabeth they became so pronounced that the House of Commons acted to suppress many of those exclusive franchises. The crown still could and did make other grants, however, so a Committee of Grievance was appointed by parliament during the reign of James I, and eventually the Statute of Monopolies was passed in 1624. It declared void all monopolies that were "grievous and inconvenient to the subjects of the realm." Exception was made, however, of monopolies that might be granted by parliament or of those that arose by virtue of new manufactures or inventions.

Thus was laid down the principle that he who devises something should have the exclusive right to exploit it for a limited period. The founders of our government approved this principle by including in the Constitution of the United States a provision that Congress shall have power "to promote the progress of science and the useful arts by securing for limited times to authors and inventors the exclusive rights to their respective writings and discoveries." During the first decades of the new republic, the granting of patents rested in the hands of three cabinet members: the secretaries of State and War and the Attorney General. The Patent Office was established in 1836, and the basic laws that govern our patent system were enacted at that time.

Americans are prolific inventors, especially in times of war. During recent years they have poured applications into the patent office in such a steady stream that approximately 123,000 of them are still awaiting action. The normal rate at which they are handled is about 500 a week, so the backlog represents some five years of work at the present pace. All told, nearly 2,500,000 patents have been granted since our nation was set up.

Our patent system has recently been assailed; but, while it undoubtedly is vulnerable at some points, it can be defended as a whole. A patent is admittedly a monopoly, a word that is anathema to some of our citizens who would like to share their neighbors' hard-earned possessions instead of working to create or acquire some of their own. Monopoly is not the fearsome thing that it has been painted. Every person who owns a piece of property or a home has a monopoly, and the law gives him the right to exclude uninvited guests from it.

That is what the patent law does with respect to an inventor's ideas. It gives him protection for a period of seventeen years. The idea is his property and no one else is permitted to share in its benefits until he has had a reasonable time to reap reward for his industry and ingenuity. He can either put the patent to use, or he can sell it and let the buyer do so. After the expiration of the seventeen years the patent becomes public property forever.

Without this incentive—this opportunity to reap financial gain—it is obvious that we would have a muddled situation. Inventors might still invent, but they certainly wouldn't rush to the patent office to publish their ideas. Instead, they would guard them zealously, and industrial plants that exploited them would be closed to visitors and subject to espionage from competitors.

Those who advocate doing away with the monopolistic privilege the law gives an inventor have perhaps not thought the matter through. Such a change would stifle, rather than stimulate, the creative urge. As matters stand now, as soon as one manufacturer brings out a desirable product that is protected by patent, all competitors at once try to devise something equal or superior for the same purpose. Knowing that they will do this, the patentee also works to improve his product. As a result there is healthy competition that brings about continual betterments. But suppose the original patent immediately became public property. All who wished to avail themselves of it could do so and the tendency would be to let the other fellow do the inventing and then take advantage of his efforts.

America has come far under its present patent system, and there would seem to be no great need to make drastic changes now. So long as there is the promise of ample financial rewards, men will go on devising new things and vast new vistas will be opened up in the realm of science. To remove the incentive that the law affords would be to put the brakes on achievement and bring about a static condition. In 1844 the Commissioner o Patents declared that we were nearing the time "when human improvement is at an end." Again in 1875, it was predicted that "scientific inventions can take us only a little further." In view of the progress that has been made since then, nobody is foolish enough to make such statements now. The whole field of nuclear energy remains to be developed, and we have only started to learn how to conquer many of the diseases that take a heavy toll of life. Let us continue to make it worth while for inventors to work to prolong our lives and add to our comfort while we remain on this mundane sphere.

BOULDER DAM'S BIRTHDAY

THE tenth anniversary of power production at Boulder Dam was observed on October 23 with appropriate ceremonies. Although larger dams have been built since the Colorado River structure went into service, and still greater ones are in the offing, it is and promises to remain for some time the most famous one of all. This is so because it was the pioneering effort in the realm of high dams, a daring, precedent-shattering engineering adventure that marked the dawn of a new era in hydraulic construction. The anniversary is of particular significance to this publication not only because compressed air played a vital part in the undertaking but also because it devoted more space to describing the building of the dam than did any other periodical.

Boulder Dam is a monument to man's mastery over Nature. Less than a century ago, in 1857, Lieut. J. C. Ives traveled up the tempestuous Colorado almost to the exact site the dam now occupies and then gladly turned his paddle-wheel boat *The Explorer* downstream after writing a doleful account of what he had seen. "The region," he reported, "is altogether valueless. It can be approached only from the south and, after entering it, there is nothing to do but leave. Ours was the first, and doubtless will be the last, party of whites to visit this profitless locality. It seems intended by Nature that the Colorado River along the greater portion of its lone and majestic way shall be forever unvisited and unmolested."

Lieutenant Ives could not, of course, foresee the conquest of the turbulent, unruly stream that was to make water and power available hundreds of miles away on the Pacific Coast. He could not conceive that men would have the audacity to tackle such an awe-inspiring undertaking as Boulder Dam, or that they could devise methods and machinery for carrying out the scheme.

The Bureau of Reclamation, which built the dam, looks upon it as the beginning, rather than the end, of the development of the Colorado River Basin and stands ready to go on with the second phase of the job. It has prepared a comprehensive report, based on years of studies, showing that not quite half the average annual flow of the river is being used today. The long-range plan includes 134 additional potential projects that would utilize the surplus water to irrigate some 2,600,000 acres of land that is now dry or inadequately watered.

The successful rearing of Boulder Dam directed international attention to the skill and resourcefulness of American engineers and construction men, and enlarged man's vision of what can be accomplished in turning natural resources to beneficial service.

Machines Expedite Tire Production

MACHINES TAKE OVER HANDWORK

At the left is the tire-mounting machine with the arm in "down" position ready to force the bead into place as the table slowly turns the wheel assembly on top of it. Six of these units are in use, and each can mount about 80 tires an hour. The other picture shows the equipment designed for continuous tire inflation. As soon as one is removed from a nest at the unloading station another takes its place, and each is charged at the desired pressure in the time it takes the table to make one complete cycle. There is a separate air line for each nest, of which there are eighteen. Both machines were designed and built by Ford.

TWO new machines that are helping to meet the great demand for tires to keep the American public on wheels have been developed by engineers of the Ford Motor Company and are in use in its Rouge plant. One mounts tires, work that was done by hand before the war put a stop to the manufacture of civilian cars. At that time natural rubber was the basic raw material for tires, but when it became necessary to make them of synthetic rubber it was found that the stiff casing could not be handled fast enough manually to meet production needs. Here was a problem for the engineering department, and the equipment that was designed there to take over the job enables an operator to mount tires at the rate of more than one a minute. The other unit inflates the tires.

The mounting machine consists of a revolving steel table on a pedestal to which is attached an arm provided with two rollers. On the table is placed an automobile wheel and on top of the latter is laid a tire casing with the tube inside. The operator then starts the casing bead under the projecting rim of the wheel and brings down the arm to hold the bead in the rim slot. With that done, pressure on a foot pedal sets a motor going, and as it turns the table the rollers on the arm force the bead in place.

The mounted tire then travels by conveyor to the inflation machine, a sort of merry-go-round affair equipped with eighteen nests and as many air lines tapping a centrally disposed air receiver that draws its supply from the plant air line. The pressure at which the tank is charged is predetermined and is maintained constant by a reducing valve. A motor rotates the table at slow speed, and as the operator puts a wheel in a nest he clamps the associate air hose to the tire valve. Upon reaching the unloading station at the completion of the cycle the tire is inflated, as required—is under the same pressure as the air receiver. The operator then disconnects the air hose, removes the wheel, and puts another in the nest for a trip around.

Steel-Making Practices in Germany

TO REDUCE the high nitrogen content of basic Bessemer steel, which makes it unsuitable for many applications, the Germans maintained relatively low temperatures in the converter and shortened the time of blowing air through it, according to a report issued by the Office of Technical Services, Department of Commerce. At the August Thyssen Works in Hamborn, cold steel scrap was added after a blow had been 70 to 80 percent completed, and the air blast was enriched with oxygen to accelerate the conversion of iron to steel. Efforts likewise were made to reduce the nitrogen content of the iron and coke used in making the steel. Further, aluminum, titanium, silicon, and zirconium were added to the converter during the blowing period to remove nitrogen in the form of nitrides.

At the Krupp Works, plans were underway to increase the oxygen blast for basic Bessemer converters up to 30 percent, but the equipment was not installed. Plant personnel stated that this would have cut the average blowing time from 20 to 15 minutes, permitted the use of 6 percent more scrap, and reduced the phosphorus and sulphur content of the steel. Oxygen enrichment of the blowing air also was scheduled by Krupp. Officials expressed the belief that increasing the oxygen content to 25 percent would increase the quality of the pig iron for steel-making purposes and reduce blast-furnace coke consumption.

Multiple Air Gauge Forms Part of Production Line

DESIGNED as an integral part of a production line, the multiple-spindle Precisionaire recently announced by the Sheffield Corporation has set a high in air gauging. The instrument checks eight cylinder bores of an automobile engine block for diameter, taper, and out-of-roundness. It does this at four different points in each cylinder, or 32 points in all, and is said to classify them with accuracy to 0.0003 inch.

The engine blocks are brought to the gauge by a conveyor, where loading arms pick each one up and advance it to the measuring position. There two hydraulic plungers, together with a shot bolt that fits into a locating hole in the top of the block, spots it and holds it in place. When aligned, eight spindle assemblies automatically enter the eight cylinder bores. Each assembly consists of four spindles that float independently to allow for tolerance in hole spacing. Upon reaching the limit of travel, the spindles come to a halt and can be rotated manually through 180° for out-of-round inspection. In the event any one of the eight sets encounters interference, the machine stops and a red light indicates the incorrect cylinder bore.

At eye level, each spindle assembly has four Precisionaire tubes to indicate its findings, and alongside the right-hand tube is a scale graduated in 0.0003 inch and marked off in selection sizes numbered 1 to 10. When gauging an engine block, the floats fall in the tubes to a point opposite a number on the scale. The movable tolerance slide is then positioned to determine if all four floats are within the out-of-round and taper limits of 0.0007 inch. If so, the selection size is indicated by the number opposite the float in the right-hand tube. This number is stamped on the block alongside the several cylinder bores by a manual marking device mounted above each spindle assembly. With this done, the spindles are retracted, the engine block travels along the production line to the next operation, and another block moves into gauging position.

MULTIPLE-SPINDLE AIR GAUGE

Built for the Buick Division of General Motors, this precision instrument simultaneously gauges bore diameters of an automobile cylinder block at 32 points. It is about 4 feet wide, 8 feet long, and 7 feet high, and can measure with accuracy to one ten-thousandth of an inch. Hydraulically operated, electrically controlled, and gauging by air flow, the Precisionaire is said to complete a cycle in less than 60 seconds, thus checking engine blocks at the rate of more than 60 an hour.

Refining Aluminum Airplane Scrap for Reuse

"UNIQUE in metallurgy," are the words by which American and British investigators have described a German filtration method for refining aluminum scrap for reuse in all but the most critical parts of airplanes. When the war ended, there were numerous plants in that country engaged in this salvage work, among them I. G. Farben at Bitterfeld. Scrap arriving there was sorted with a minimum of hand labor, and that containing aluminum alloy was charged into the stack of a gas-fired furnace having two sloping hearths. Melted aluminum and other components with low melting points flowed down a sloping channel into rectangular forehearths with a capacity of approximately 1 ton. When one was full, the stream was directed into a second one. Unmelted iron and other scrap was raked out through a door in the upper level of the hearth.

If necessary, the aluminum was further refined by filtration, followed by vacuum distillation. This was done by adding an excess of molten magnesium to the melted aluminum alloy, thus forming insoluble intermetallic compounds of aluminum and magnesium with iron, manganese, silicon, chromium, vanadium, molybdenum, titanium, zirconium, and cerium. These compounds could be filtered out as crystals when the mixture was cooled to a point close to solidification. What remained was heated in an atmosphere of hydrogen at a pressure of 2 millimeters of mercury in a closed furnace. By this means all the metals except copper and small amounts of nickel and tin were distilled out. Inasmuch as the refined aluminum was intended for use in copper-bearing duralumin alloys, that residue presented no problem.

A complete report on the subject, entitled *Recovery of Metals from Scrapped Airplanes* (PB-23188), in microfilm or photostat form, fifty cents and two dollars, respectively, may be obtained by sending check or money order payable to the Treasurer of the United States to the Office of Technical Services, Department of Commerce, Washington 25, D. C.

Fifteen merchant vessels that were scuttled at the mouth of the Loire to block the port are to be repaired in the dry by diverting the broad stream for a distance of one mile. This is an unusual method of harbor clearance, but was decided upon by the French engineers because of the treacherous nature of the river which would have made underwater salvage too risky an undertaking. With the work of repair completed, the Loire is to be returned to its normal course. The cost of the project is estimated at $84,000,000 and will be more than covered by the ships, which include the 20,000-ton *Antartis*, said to be the world's largest whaler, and the *Fatouville*, Europe's best-equipped dredge. Some of the vessels are lying at a depth of 40 feet.

Studs Tested with Helium Under Pressure

CHECKING FOR OILTIGHTNESS

Each of the 177 studs in this transformer cover plate was tested by a leak detector (right). The man at the left is holding a can of helium over the head of a stud, while another covers the threaded end with a vacuum cup connected to the recording instrument. If any gas was drawn through the stud hole when suction was applied, the stud was faulty. Possible concentrations of helium in the atmosphere were prevented from reaching the detector by training an electric fan on the can of helium.

THOUGH designed primarily for a specific purpose, the General Electric leak detector for vacuum lines has proved to be adaptable. It was recently used to advantage in testing the tightness of 531 studs in the cover plates of three oil-cooled transformers being built for the Consolidated Edison Company. Work of this kind is normally done by a soap solution applied by compressed air, bubbles at any point indicating leakage. In this case, however, the method would not do because the penetrating solution would have left a deposit of soap under the heads of the studs that ultimately would have contaminated the oil in the transformers.

The function of the G-E leak detector is to indicate the presence of helium. Therefore a can of this gas was applied to the head of each stud and subjected to approximately 2 pounds pressure. Over the threaded end of the stud on the underside of the plate was placed a vacuum cup, and this was connected through a valve to the leak detector. If any helium was sucked through the gasketed stud hole, the output meter of the detector recorded that fact. An interval of 30 seconds was allowed to elapse before the pressure valve on the helium can was closed, and if no reading was registered on the meter in that time the test crew removed the can and the cup and placed them over another stud. After becoming familiar with the procedure, the crew of three men was able to test a cover plate, or 177 studs, in two days with accuracy and without danger of subsequent contamination of the oil.

Advance in Powder Metallurgy

THE field of powder metallurgy, according to a U. S. Army research report, may be broadened through the discovery that nonflowing, finely divided metal can be made to flow by waterproofing the individual particles. The experiments that led to this conclusion were conducted at the Watertown, Mass., Arsenal Laboratory and were made with iron powder, which is one of the most highly pulverized metals available and typical of those generally considered unsuitable for powder metallurgy because of their poor flow rate.

Investigations proved that condensation of moisture on metal particles causes them to flow slowly or erratically, and in some cases not at all. But when a thin film of methyl chlorsilanes, a waterproof substance developed during the war, was deposited on the iron powder by a vapor treatment, the zero flow rate rose to 80 percent of that of a standard silicon-carbide powder. Bars of the material produced at 150,000 pounds pressure per square inch and sintered at 2012°F. showed no impairment of mechanical properties, and the film did not appear to prevent diffusion and bonding during sintering. Increased fluidity brought about a slight rise in the density of the powder, permitting the use of shallower mold cavities and uniform filling of complicated molds. There is also a possibility that waterproofed powder may withstand long storage without deterioration from atmospheric conditions, and that the chlorsilanes treatment may check the tendency of very fine powders to burn or explode upon contact with air.

Spile-Driving by Scraper Hoist

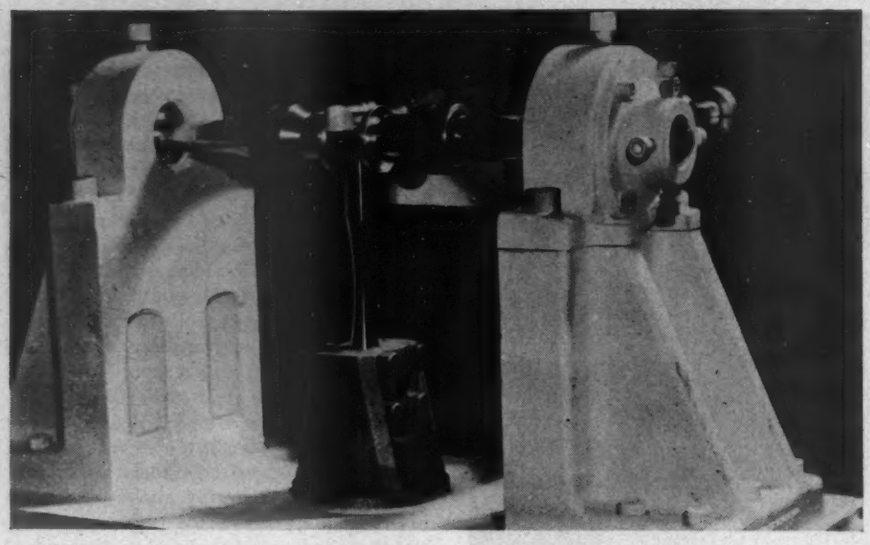
SLUSHER or scraper hoists that have revolutionized the work of underground ore handling are seen in a new role in the Negaunee Mine of the Cleveland-Cliffs Iron Company. There they have taken over another back-breaking job—that of driving spiling—which was formerly done by hand with a sledge. The idea of rigging up such a hoist for that purpose was conceived by two employees of the mine, and the device bears the strange name of "Glory Be," the ejaculation made by a fellow worker when he saw how well it performed.

Through the courtesy of the U. S. Bureau of Mines we are able to show the contrivance ready for action. The hoist itself is not in the picture, but the ½-inch cable leading from it is shown threaded through a snatch block and pulley, mounted in a recess at the near end of the "Glory Be," and firmly anchored to the I-beam at the right. The unit is made of 5- or 6-inch standard piping and has an over-all length of 2 feet. When power is applied to the hoist, the spile, which is inserted into a socket at the far end of the pipe, is driven into place. However, in the case of heavy compacted ground it may be necessary to use a double-block arrangement.

TAKES OVER HARD JOB

Underground view of Negaunee Mine showing how the hoist cable is anchored and threaded through the snatch block. The other end of the contrivance is hollow and is shoved over the spile to be driven.

Fatigue Tester Works on Principle of Slide Trombone



FATIGUE TESTING MACHINE

The test specimen is mounted between opposing air tubes and is vibrated with tuned air until fatigue causes breakage. This occurs when the frequency or vibrations of the air impulses and those of the sample are out of phase. Direct reading of displacement and frequency are obtainable by suitable instruments.

AT THE recent Buffalo meeting of the American Society for Testing Materials, F. B. Quinlan, of the Schenectady Works Laboratory of the General Electric Company, described a pneumatic fatigue machine of his devising for testing turbine buckets, small assemblies, and a wide range of parts and specimens. The operating mechanism of the device consists of a tuned air column in which tuning is effected by decreasing the length of the air path much as the player of a trombone changes the tone of his instrument by moving the slide.

The test piece is placed in such a position between two pneumatic tubes or cylinders that the air issuing from the open ends strikes against the upper part of the specimen, causing it to vibrate at the same frequency as the note in the air column. This continues so long as air flows through the opposing tubes and until the vibrations of the sample are out of phase with those of the air. Then breakage occurs.

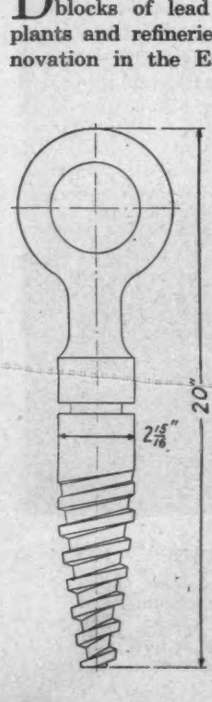
The frequency of the air impulses and the natural frequency of vibration of the specimen can be coördinated by adjusting the length of the tubes, and this makes it possible to obtain large and stable amplitudes of vibration with comparatively small amounts of air. The fatigue tester, says Mr. Quinlan, has produced stresses as high as 100,000 pounds per square inch with no more air than that supplied by the average vacuum cleaner.

By the aid of a recording frequency meter it is possible with the instrument to obtain preliminary data of great value to the designer and the engineer. In short, the chart indicates what appears to be the point of incipient failure. In the case of brittle material, this point is very close to that of complete fracture, while in that of ductile materials it is indicated long before fracture is visibly apparent.

The pneumatic fatigue machine has no parts to wear out because the only thing that moves is the part that is to be broken. Three different models have been built: the one described, another for torsion testing, and a third for strip testing. All operate on the same principle, but differ in size and arrangement for holding the work. With the exception of the strip-fatigue machine, all assemblies or specimens may be tested at temperatures from below zero to 1700°F.

Big Screws Solve Handling Problem

DIFFICULTIES in handling large blocks of lead bullion at drossing plants and refineries have led to an innovation in the East Helena (Mont.,) plant of the American Smelting & Refining Company that has solved the problem, which has been one of long standing. The latter plant is equipped to produce 10-ton blocks, which are now removed from the molds by means of screws each 20 inches long and provided with an eye. Except for the eyes, these are embedded in the lead at fixed points.



Two screws are set in each mold on the longitudinal center line and are held in position during casting by removable angle irons and a ball-and-socket arrangement. Hooks attached to a crosspiece suspended from an overhead crane fit into the eyes to lift the load. Six blocks, usually the average weight a gondola car will carry, are cast at a time. Unlike the steel anchors that were previously embedded in the blocks, the screws are removed before shipment. This is done easily, it is claimed, by inserting a steel bar in the eye of each one and giving it 2¼ turns. The hole is then filled with a 3-inch lead plug that is peened into place.

At the receiving end, unloading is done quickly either by the aid of chains or a special type of double-jaw tongs made by the Heppenstall Company. The latter lock automatically in open position and permit the craneman to do the work without any other assistance. If chains are used, they fit into recesses at the ends of a block that are deep enough to prevent slippage. The handling system is reported to be satisfactory from every standpoint—from that of the smelter; the railroad, because it releases cars without delay; and the refiner.

Error Found in "Pi"

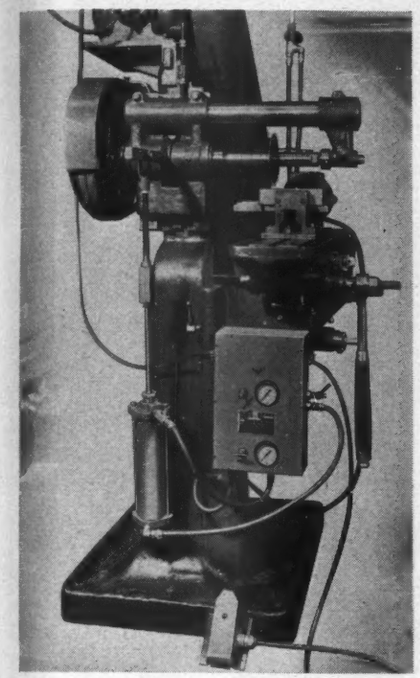
OF MORE academic than practical importance is the report that an error has been found in the mathematical figure known as *Pi*. It is an error that will bother few persons, for it comes after the 530th decimal place. D. F. Ferguson, of the Royal British Naval College, is the mathematical sleuth who brought it to light and who has given the world new figures extending from the 531st to the 540th decimal places.

Curiosity aroused by the news of the correction have caused us to add the following information to our previous meager knowledge of *Pi*. It was first calculated by a Dutch mathematician, Ludolph van (or von) Ceulen (also written Keulen and Collen), who lived from 1540 to 1610. He was professor of fortifications at the University of Leyden. His wife aided him in the calculation, but no blame can be attached to them for the error just noted because they contented themselves with working out the figure to a mere 35 decimal places. Others subsequently extended it to astronomical proportions, and it appears that a mathematician named Shanks had a leading part in this prodigious task.

The work that van Ceulen did was considered of such importance by his contemporaries that the figure 3.14159625 and so on to 35 places was engraved on his tombstone at Leyden. In his honor, *Pi* is sometimes called Ludolph's Number.

Industrial Notes

A new low-voltage electro-pneumatic control that permits conversion of standard machine tools and fixtures into automatic or semiautomatic production equipment has been announced by the Electro-Air Devices Company. It combines in one unit a step-down transformer (115-220 volts alternating current to 24 volts), manifold-type solenoid valves, pressure regulator, needle valves, and armature



housed in an enamel-finished steel case that can be quickly mounted anywhere on a machine without hampering operator movement or vision. According to the manufacturer, the device may be used with any standard pneumatic cylinder and can be furnished to provide single or multiple-cycle control with the addition of cycle timing, hesitation limit switches, etc., to perform a wide variety of operations such as automatic drilling, tapping, milling, indexing, and holding. Pressure selection over a wide range to meet job requirements is fast and accurate and makes for the economic use of air power.

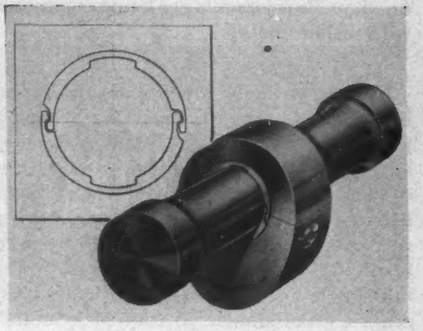
Helium is cast in the role of detective in a technique developed by the U. S. Bureau of Mines and the Navy to ferret out the movement and extent of oil and gas deposits. Helium is suited for the part because it is chemically inert, and upon introduction into a stream of other gases or liquids emerges at the outlet unaltered. In practice, helium is injected into wells. Observation of the points at which it escapes provides data on the contour and extent of the reservoir, while helium concentration is an indication of its character. The method was tried out at the Navy's Elk Hills oil reserve and is said to be of especial value in recycling gas—returning it to underground storage—and in increasing underground pressure to force out more oil.

Cold-process roofing materials introduced some years ago by The Flintkote Company for new construction and maintenance are now available in a form suitable for application by air spray. This method of putting on both adhesive and top coatings enables operators to reach out-of-the-way places with safety and to do the work in two-thirds the time.

Materials such as paper, textiles, leather, wood, etc., that are ordinarily damaged or burned by exposure to heat are being coated with metal that is sprayed on in the molten state. The secret lies in covering the surfaces with a protective film such as a glycerine solution that vaporizes during the application of the metal and leaves no residue. The coatings adhere firmly to the inflammable material even when subjected to mechanical stresses.

To facilitate the construction of stairways in factories and commercial plants, the Home Ola Corporation is offering sectional steps of pressed steel. Standard unit has an over-all width of 36 inches, with a net tread and riser of 9 inches and 7½ inches, respectively. Lip extending above tread has 13/16-inch bolt holes to join sections. Time of erection for a full stairway is said to be about 90 minutes. Units can be placed end to end for wider steps, and can be painted any standard color, carpeted, or protected with rubber treads.

A new retaining ring designed especially for equipment with a high rpm. rating has been announced by Waldes Kohinoor, Inc. It is of 2-part interlocking construction and, when fitted over a shaft in a radial direction, forms a complete annular shoulder of uniform section height, thus eliminating the wide gap characteristic of conventional open-type C rings and increasing the normal thrust capacity. Because of its positive



interlocking action, says the manufacturer, the unit is not lifted out of its groove by high centrifugal force or by linear expansion caused by friction. Disassembly is effected by slight prying with a screw driver. The product is known as the Truarc Interlocking Ring, Type 5107.

According to press reports, a Soviet metallurgist has invented a new process of "casting" metals. It is described as a method of frosting or crystallization, and the mold used is designed to circulate cooling water along the inner walls. Instead of pouring the metal, the mold is immersed in the molten mass and allowed to remain there until the outer face is covered with an even layer of prede-

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termined thickness. Bronze bushings produced in this manner are reported to have a smooth surface and to be of high quality. Experiments are being conducted with other metals.

•

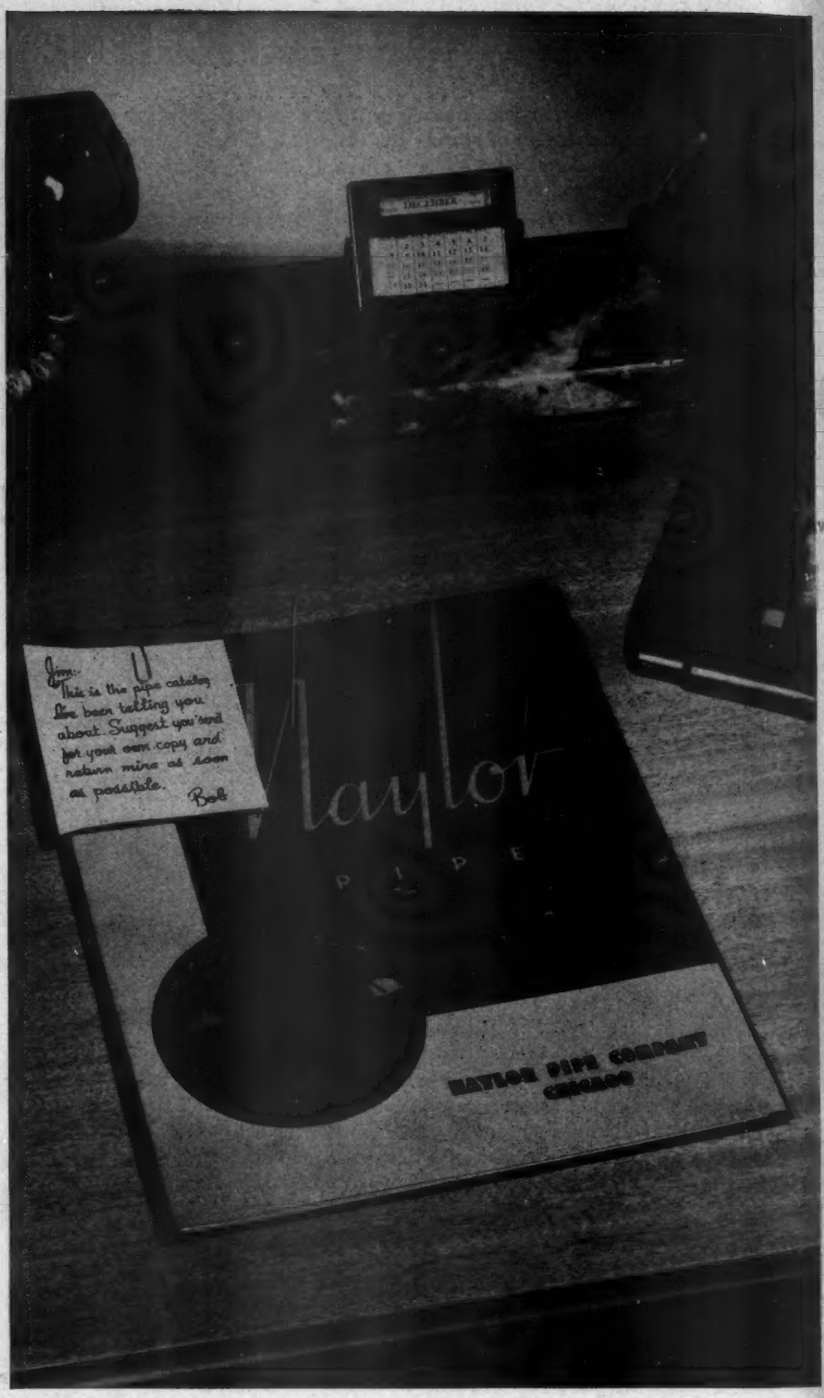
The jet principle of propulsion is used in a new toy racing boat for which a patent has been issued. Air contained in an inflatable rubber balloon in the hull is discharged through a tube having its outlet underwater at the stern, thus serving to drive the craft at a fair rate of speed until the air supply is exhausted. The bubbles of air rising to the surface produce a wake similar to that of a motorboat.

Atlas Powder Company has announced a blasting system—the Rockmaster—for quarrying, mining, and construction operations that is said to be an entirely new development of the delayed-action principle. Drilling, type of explosive, and timing of detonation are all taken into consideration in planning a blast, with a resultant increase in production and fragmentation and decrease in secondary shooting. It is further claimed that there is less complaint on the score of noise and vibration.

By attaching rubber bladders to the treads of amphibious-type caterpillar tractors, the Japanese army added measurably to their buoyancy in water and enabled them to "float" over swampland. In the case of a 5-ton-capacity crawler, the bladders gave each track a bearing surface of about 37 square feet on level ground. They were inflated by foot-operated bellows with air at from 3 to 5 pounds pressure. The units were driven by an air-cooled gasoline engine and steered when afloat by a propeller at the rear.

To its line of pneumatic door-opening and control equipment, the National Pneumatic Company has added packaged kits for industrial plants and for installation by the user. They are designed for

new or existing single sliding doors, level or inclined tracks, and for openings ranging from 2 feet 6 inches to 8 feet and wider. Standard units require air at from 80 to 100 pounds pressure. Opening and closing speed is preset, but can be regulated by adjustment screws. Once the action is cushioned and timed as desired it is auto-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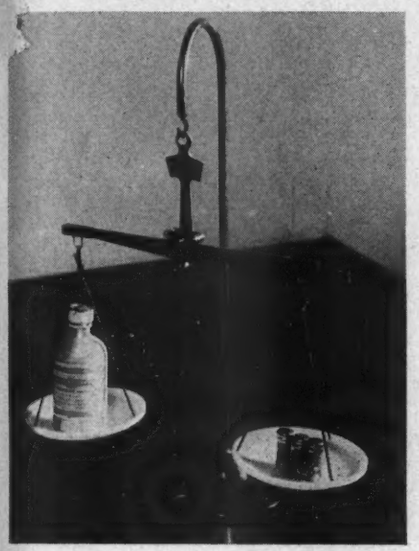
matically maintained so long as the air supply is turned on. For the passage of cars or trucks, door operators can be made to function by remote control and, where it is vital to isolate hazardous areas, one or a number of them can be interlocked and hooked up as well with fire-detection equipment. Manufacturer has specialized for years in equipment of this type for elevated trains, subways, trolleys, and buses.

Though scaled to precision, SKF Industries, Inc., is using mass-production methods to make metal balls, half the size of a pinhead, for new-type fountain pens, as bearings for instruments, and for other delicate applications. Despite the fact that they are of steel, a so-called base metal, they are about four times more valuable, weight for weight, than gold.



In the accompanying illustration, four quarter-ounce bottles containing 7000 of the tiny spheres are balanced with a like weight of hyperessence of violet leaves—an extract so rare that a ton of the flowers' foliage yields only an ounce of it. Both the perfume oil, imported from France, and the steel bearings cost $125 an ounce.

Electric heaters are a familiar article, but an electric radiator that is never too hot to touch and yet keeps an entire room warm sounds revolutionary. These are claims made for the Morton Co-Z-Air that is built on the same lines as the conventional type but uses no water or steam. It operates on a dual-heat principle—radiation and convection—and, in addition, draws in cold air at floor level and expels it through concealed vents, heating it in its passage through the piping. Unit is simply plugged into any electric outlet and is said to require about the same amount of direct or alternating current as a toaster or an electric fan. It comes in two sizes and eight models and is equipped with a handle that can be used as a drying rack.

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Industrial Literature

A new catalogue, No. G-12, describes pressure gauges of various types that are made by Gotham Instrument Company, Inc., 149 Wooster Street, New York 12, N. Y.

The Sturdy Tool & Gage Company, 14520 Schaefer Highway, Detroit 27, Mich., has issued a catalogue describing its line of precision gauges. They are made of chromium-plated steel, tungsten carbide, and Norbide.

A revised edition of the Sun Oil Company's bulletin, *Lubrication of Diesel Engines*, is available upon request to 1608 Walnut Street, Philadelphia 3, Pa. It briefs the history of diesels, describes the operating features of the various designs, and devotes 24 pages to a discussion of their lubrication.

The use of rubber belting and hose in the construction industry is featured in a new pictorial bulletin, *Manhattan Rubber Products for Contractors*, that is obtainable from Raybestos-Manhattan, Inc., Manhattan Rubber Division, Passaic, N. J. The illustrations show applications of the company's products on outstanding construction jobs such as the Delaware River Aqueduct, George Washington Bridge, Norris Dam, and many others.

A 34-page booklet discussing the effect of concrete and mortar shrinkage and means of controlling or eliminating it is offered by The Master Builders Company, 7016 Euclid Avenue, Cleveland 1, Ohio. That concern manufactures Embeco, a metallic aggregate for mortar mixes that has the property of expanding during the setting and curing stages and thereby filling voids. The booklet is titled, *The Action of Embeco in Concrete and Mortars*.

A new bulletin on Class V2 bent-tube boilers is available upon request to Henry Vogt Machine Company, Tenth and Ormsby streets, Louisville, Ky. In this type of boiler a large proportion of the tube surface is exposed to the furnace heat, and the design is such as to permit its adaptation to a limited space when necessary. A large part of the bulletin is devoted to sectional drawings and data tables on typical industrial installations.

Thermix Engineering Company, Greenwich, Conn., has issued a bulletin, No. 310, describing the Aerotec integral dust collector which is designed for use in connection with grinding and buffing operations. The collector, with motor and fan, is available in a "packaged" unit for capacities of from 300 to 2100 cfm. An electrical precipitator may be attached to the collector where it is desired to increase the efficiency of the unit.

Various squeezing operations on metals, plastics, ceramics, and other materials can be performed by Air-Hydraulic presses. Typical uses are for forming, flanging, riveting, broaching, crimping, heat-sealing, and assembling. The press operates on air pressure and needs only to be connected to the plant air line. The ram delivers a pressure of 50 times the air intake pressure (5000 pounds per square inch with 100-pound air). The ram stroke is adjustable from 5 inches down to 1/16 inch. As the ram travel is lessened, the number of strokes per minute increases and the air consumption decreases. The squeezing action is constant throughout the ram stroke, and the pressure may be varied to meet the requirements of the work being done. Either a hand- or foot-controlled valve or a solenoid valve with push-button control is used to operate the machine. Units are available for either a 2- or 5-inch maximum ram stroke. A descriptive bulletin is obtainable from Air-Hydraulics, Inc., 401 Broadway, New York 13, N. Y.

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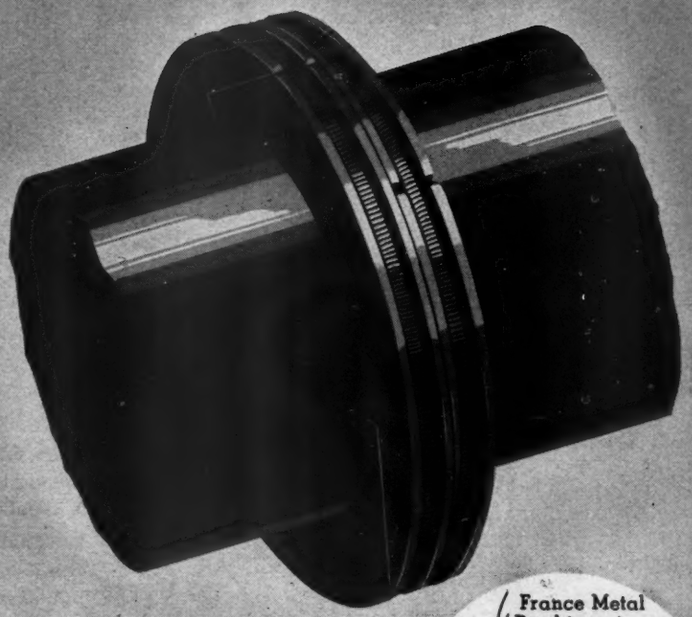

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